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PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME XVII.

NUMBER 100.

1905.

SAN FRANCISCO:

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COMMITTEE ON PUBLICATION.

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Washington, District of Columbia, The American Ephemeris.
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William's Bay, Wisconsin, Yerkes Observatory.
Zurich, Switzerland, Observatory.

EXCHANGES.

Astrophysical Journal, William's Bay, Wisconsin.
Sirius, Cologne, Germany.
The Observatory, Greenwich, England.

FOR REVIEW.

[See *Publications*, A. S. P., vol. VIII, p. 101.]

The Call, San Francisco, California.
The Chronicle, San Francisco, California.
The Examiner, San Francisco, California.
The Mercury, San José, California.
The Record-Union, Sacramento, California.
The Times, Los Angeles, California.
The Tribune, Oakland, California.

PLANETARY PHENOMENA FOR MARCH AND APRIL, 1905.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

New Moon, March	5,	$9^h 19^m$ P.M.	New Moon,	April	4,	$3^h 23^m$ P.M.
First Quarter,	" 14,	1 0 A.M.	First Quarter,	"	12,	1 41 P.M.
Full Moon,	" 20,	8 56 P.M.	Full Moon,	"	19,	5 38 A.M.
Last Quarter,	" 27,	1 35 P.M.	Last Quarter,	"	26,	3 14 A.M.

The Sun crosses the equator from south to north and the vernal equinox occurs about 11 P.M. March 20th, Pacific time.

The second eclipse of the year occurs on March 5th, and is an annular eclipse of the Sun. No portion of it will be visible in the United States. The path of the central eclipse lies in the Southern Ocean, and the only large island crossed is Australia.

Mercury is a morning star at the beginning of March, too close to the Sun to be seen. It comes to conjunction on March 9th and becomes an evening star, but does not get far enough away from the Sun to be seen in the evening twilight until the last ten days of the month. From about March 20th until the middle of April it remains above the horizon an hour or more after sunset, and may be seen under good weather conditions in the evening twilight near the western horizon. It reaches its greatest eastern elongation, 19°, on April 4th, and then sets considerably more than an hour and a half after the Sun. The few days about this time afford the best opportunity of the year for seeing this planet. The number of days during which it may be easily seen is not as great as it is at other times, as the elongation is at best not up to the average, since the planet passes perihelion only nine days before greatest elongation, and its motion in space is most rapid when at perihelion. It comes to inferior conjunction with the Sun on April 23d and will for the following two months be a morning star.

Venus will still remain an evening star until April 27th. It then passes inferior conjunction with the Sun and becomes a morning star. On March 1st it sets nearly four hours after sunset. The interval shortens up about an hour during March and diminishes still more rapidly in April, but does not get

below one hour until nearly April 20th. However, the planet may be seen until within a very few days of conjunction on account of its nearness to us and consequent brightness. The time of maximum brilliancy comes about half-way between greatest elongation and inferior conjunction, on March 21st, and for a number of weeks the planet is bright enough to be seen in full daylight. It will not be very easy to find it while the Sun is up, unless one knows just where to look for it, but it is fairly conspicuous when once found.

Mars as it draws near its opposition in May becomes more and more prominent. It rises at about 11:30 P.M. on March 1st, at about 10 P.M. on April 1st, and before 8 P.M. at the end of the month. During the two-months period its distance diminishes from ninety-two to fifty-two millions of miles, and there will be in consequence more than a threefold increase in brightness. It will be by far the most conspicuous object in the southeastern sky, just as *Jupiter* and *Venus* hold similar positions in the western sky in the evenings. Its motion among the stars during the spring and summer months affords a good opportunity for the study of the retrograde motion of a planet near opposition. On March 1st it is in *Libra*, and during the month it keeps up its general eastward motion, moving about 5° toward *Scorpio*. This eastward motion gradually ceases, and on April 2d it begins to retrograde (move westward). By the end of the month it is back again near to the place it occupied on March 1st, about 1° south. This retrograde motion will last until the middle of June, and then the planet will be about 3° south of the place it held among the stars on February 1st.

Jupiter is still an evening star, but the Sun is gradually overtaking it in their common eastward motion. It does not set until nearly 10 P.M. on March 1st, but by the end of April the planet is nearly in conjunction with the Sun and sets about ten minutes after sunset. It cannot be easily seen more than a few days after the middle of April.

Saturn is a morning star, rising about half an hour before sunrise on March 1st. This interval increases to nearly three hours before the end of April. It moves about 5° east and north in the constellation *Capricorn*.

Uranus rises at about 3 A.M. on March 1st, and at about

11 P.M. on April 30th. It is nearly stationary in the constellation *Sagittarius*, and begins to retrograde on April 8th.

Neptune is almost exactly opposite *Uranus*, rising when the latter is setting, and *vice versa*. It is in the constellation *Gemini*, and is above the horizon while *Uranus* is below.

VARIABLE STAR NOTES.

By Rose O'Halloran.

After an absence of some years, the interesting maxima of *o Ceti*, or *Mira*, The Marvelous, have at length returned to the evening sky. As only new stars rival its range of variation, from ninth to second or third magnitude, its recent visibility has no doubt been widely observed. The minimum of October last was below the average, and it will be of interest to note if the coming maximum be greater or less than usual. Six observations, extending from October 3d to November 5th, showed that the companion-star of ninth magnitude was about two tenths brighter than *Mira*. On November 8th a hazy reddish aspect was noticeable in the variable, and, though the companion was more sharply defined, they seemed of equal brightness.

The magnitudes of adjacent stars given in a chart of the *Durchmusterung* were used for comparison during the subsequent rise to visibility.

1904.

Nov. 27. Of 8.8 magnitude.

Dec. 2. Of 8.5 magnitude.

Dec. 16. Of 8th magnitude.

Dec. 24. Of 7.7 magnitude.

1905.

Jan. 1. About 7½ magnitude. It is reddish and visible in an opera-glass.

Jan. 3. 7.3 magnitude. Dimmer than 71 *Ceti*.

Jan. 10. Greatly increased in brightness. Brighter than 71 *Ceti*, and nearly as bright as 70 *Ceti*. Probably of 6th magnitude.

Jan. 17. Brighter than 67 or 69 *Ceti*, classed as 5.5. Less than *S Ceti*.

Vicinity of *Y Cassiopeiæ*.

Y Cassiopeiæ.

In contrast to *o Ceti* is *Y Cassiopeiæ,* known but a few years, and ranging from less than 9th magnitude to 13th in a period not yet very accurately ascertained. A recent maximum observed as follows does not accord with prediction:—

1904.	
Sept. 2.	Of about 11th magnitude. Brighter than *k,* classed as 11.3.
Sept. 6.	Some steps brighter but less than *h* of 10.4 magnitude.
Sept. 12 to 18.	Not noticeably increased.
Oct. 3.	Brighter than *h,* less than *g.*
Oct. 11.	Equals *g.* Brighter than *h.*
Oct. 16.	Brighter than *g.* Equals *c.*
Oct. 19.	Unchanged.
Oct. 28.	Brighter than *e,* less than *c* or *d.*
Oct. 30.	About midway between *c* and *d.*
Nov. 2.	Equals *c.* Night very clear.
Nov. 5, 7, 8.	The same.
Nov. 12.	Some steps brighter than *c.*
Nov. 15.	Slightly decreased, but still brighter than *c.*
Nov. 27.	Less than *c.* Equals *e.*
Dec. 3.	Less than *e.* Equals *f.* Brighter than g.

In the accompanying map the variable is inclosed in a circle.

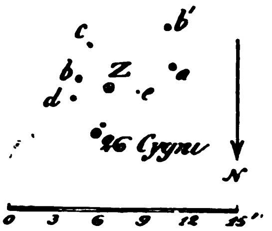
San Francisco, January 19, 1905.

ASTRONOMICAL OBSERVATIONS IN 1904.

MADE BY TORVALD KÖHL, AT ODDER, DENMARK.

VARIABLE STARS.

Z Cygni.



Jan.	17:	Z < e.
Feb.	15:	invisible
Apr.	12:	< e.
	19:	id.
May	7:	= d.
	13:	= c.
	19:	= b.
June	4:	id.
	17:	{ > b. < a.
July	7:	= b'.
	19:	= b.
Aug.	3:	{ < c. > d.
	13:	= c.
	30:	= e.
Sept.	11:	a little < e.
Oct.	9:	< e.
Nov.	6:	id.
Dec.	17:	invisible, ☾
	27:	< e.

*S Ursæ majoris.**

Jan.	17:	S = g.
Feb.	15:	< g.
	22:	invisible, ☾
Mar.	2:	id.
	12:	= f.
	28:	3 steps < e.
Apr.	2:	1 step < e.
	12:	= e.
	19:	1 step < d.
May	7:	2 steps > d.
	13:	id.
	19:	3 steps < b.
June	4:	2 steps < c.
	17:	4 steps < c.
July	7:	= d.
	19:	2 steps < e.
Aug.	3:	= f'.
	13:	= g.
	22:	invisible, ☾
	28:	= g.
	31:	invisible.
Sept.	4:	< g.
	10:	id.
	16:	invisible.
	27:	id.
Oct.	5:	11 mag.
	9:	id.
	11:	id.
Nov.	6:	= f.
Dec.	17:	2 steps < e.
	27:	1 step < e.
	28:	id.

* *Vide* the sketch in the *Publications* A. S. P., No. 73, page 56.

*T Ursæ majoris.**

Jan.	17:	T < g.
Feb.	15:	invisible.
	22:	id.
Mar.	2:	id.
	12:	id.
	28:	id.
Apr.	2:	id.
	12:	< g.
	19:	5 steps < g.
May	7:	= d.
	13:	> c. < b.
	19:	= b.
June	4:	1 step > a.
	17:	2 steps > a.
July	7:	= a.
	19:	= b.
Aug.	3:	= d.
	13:	id.
	22:	= e.
	28:	< e. > f.
	31:	= f.
Sept.	4:	a little > f.
	10:	1 step < f.
	16:	< g.
	27:	invisible, ☾
Oct.	5:	< g.
	9:	id.
	11:	id.
Nov.	6:	invisible.
Dec.	17:	id.
	27:	id.
	28:	id.

W Pegasi.†

Jan.	17:	W 1 step > g.
Feb.	12:	= e.
	15:	> e. almost = d.
	22:	= d.
Mar.	2:	= c.
Apr.	12:	> c. 3 steps < b.
	19:	2 steps < b.
May	13:	1 step < c.
	19:	id.
June	4:	= d.
	17:	id.
July	7:	2 steps < e.
	19:	< f.
Aug.	3:	= h.
	13:	< h.
Sept.	4:	id.
Oct.	9:	extremely faint.
Nov.	6:	id.
Dec.	27:	a little > g.

Y Tauri.

This star (BD 20° 1083) has been compared with A = BD 20° 1095, $7^m.4$ and b = BD 20° 1073, $8^m.2$.

Jan.	17:	Y > b.
Feb.	15:	distinctly > b.
	22:	> b.
Mar.	2:	= A.
	12:	< A. > b.
Apr.	2:	> b.
	12:	a little > b.
Dec.	28:	> b.

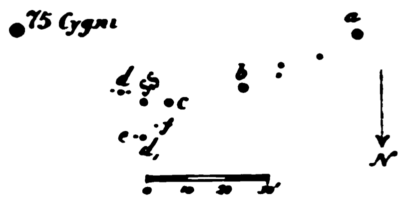
Very seldom I have seen the star fainter than b, as on 1903, January 19. when it was estimated almost = c (BD 20° 1082,

* *Vide* the sketch in the *Publications* A. S. P., No. 22, page 63.

† *Vide* the sketch in the *Publications* A. S. P., No. 60, page 23.

$8^m.5$). If we connect this minimum with the minima 1898, January 22, and 1899, April 2, a period of about fifteen months will appear.

SS Cygni.



	h			h	
Sep. 16.	9 P.M.	SS 2 steps > c.	Oct. 5..	9 P.M.	1 step < f.
	10¼	= c.	9..	9	< f.
	11¼	= c.	10..	9	id.
17..	8	= c.	11..	9	id.
18..	8	2 steps > c.	13..	8	id.
19..	9½	id.	Nov. 6..	6	< c. > d.
20..	10	3 steps > c.			
24..	9½	= e.	Dec. 17.	6	invisible, ☾
27..	8	a little < f.	27..	8½	invisible.
			32..	6	< f.

Nova Persei.

		h	m			h	m
Jan.	19......	7 P.M.	10.1	Aug.	13......	2 A.M.	10.3
Feb.	15......	8½	10.2	Sept.	4......	10 P.M.	10.4
	22......	7	10.1		10......	9	10.4
March	2......	8	10.1	Oct.	5......	9	11.0
	12......	8	10.0	Nov.	6......	8	10.1
April	2......	9	9.9	Dec.	28......	8½	10.4
	12......	9½	10.0				

The comparison-stars have been the stars in Georgetown College's Chart II, No. 42 ($10^m.1$), og. No. 49 ($11^m.0$). A decided maximum was observed on April 2d, a decided minimum on October 5th.

FIREBALLS.

Seen from stations in Denmark and surrounding countries.

No.	Time.	Beginning.	End.	Mag.	Station.	Notes.
1	April 12, 7h 45m P.M.	......	NE.	....	Vejle	
2	12, 10 22	......	NW.	....	Vejle and several places in Denmark and Norway.	A whistling was heard in Nyborg. The meteor disappeared at Christianssand in N., at Christiana in N.W. Eleven reports.
3	May 18, 9 30	......	......	....	Id.	A large fireball passed over the North Sea and left behind a curious train, which remained visible for half an hour, forming a gigantic M. Twenty-two reports.
4	30, 8 54	......	W.	*Sirius*	Nyborg...	Blue-green.
5	July 10, 9 50	......	......	....	Copenhagen....	Large light-green fireball.
6	10, 10 55	......	......	....	Odder and several places in Denmark, Norway, Sweden, and Finland.	This large fireball exploded over Dalsland in Sweden, where a loud detonation was heard. Twenty-seven reports.
7	30, 10 0	.....	......	...	Karlstad in Sweden.	A violet-colored meteor.
8	Aug. 19, 8 30	......	......	....	Ringsted........	The large meteor exploded in several parts.
9	Oct. 7, 9 0	......	......	....	Byrum (Lasö) ..	A green *cornered* meteor lighted up the whole region.
10	Nov. 26, 6 0	......	W.	....	Christiania......	A little fireball.
11	Dec. 14, 2 45 A.M.	......	......	....	Nakskov	A beautiful meteor passed slowly across the northern sky from W.—E. and lighted up the whole region. The train remained visible for several minutes.

Shooting-Stars.

As usual, in the period August 9th-12th corresponding observations on shooting-stars were arranged for from stations in Denmark and surrounding countries. At six stations 140 paths of shooting-stars were mapped, but only two proved suitable for calculation. These two meteors have given the following results:—

FOR OBSERVATION.

No.	Time.	Station.	Beginning.	Ending.	Mag.	Observer.
	h m s		° °	° °		
1	Aug. 9, 10 11 50 P. M.	Stade	46 + 67.5	57 + 69	2	V. Dohn
		Odder	292 + 11	283 — 5	1	T. Köhl
2	Aug. 12, 11 13 50 P. M.	Sonderburg..	24 + 36	15 + 30	2	M. Wolff
		Nyborg	3 + 37.5	346 + 27	2	C. Frost

FOR CALCULATION.

No.	Beginning.			Ending.			Real Length of the Path.	Radiant.
	h	λ	ϕ	h	λ	ϕ	β	*AR Decl.*
1	129	2° 9′	54° 51′	90	2° 34′	54° 34′	59	25° + 66°
2	123	0 6	55 18	96	0 40	54 59	58	59 + 47

h and β are expressed in kilometers; λ is west longitude from Copenhagen; ϕ is north latitude; h is the altitude of the meteor above the Earth's surface.

Odder and Nyborg are situated in Denmark; Stade (Hanover) and Sonderburg (Schleswig), in Germany.

DEVELOPMENT OF THE RECENT LARGE SUNSPOT.

By Rose O'Halloran.

On the morning of the 10th of January a spot of moderate dimensions was inside the northeast limb of the Sun, and on the morning following several small companion spots were in view. On the 12th, the foremost, and another some degrees in the rear, had increased considerably in size. In the foreshortened view they were oval, connected by a straggling penumbral filament, and followed by a smaller spot. The

foremost section was much enlarged on the 14th and the group extended over an area 100,000 miles in length. Clouds hindered observations on the 15th, but when observed on the 16th a general enlargement had taken place, the central section especially having developed from the smallest into the

Great Sunspot.
January 16, 1905, 10.40 A.M.

largest of the three divisions. Ten dark umbræ were distributed over the penumbral tracts which covered an area 123,000 miles in length, and 30,000 in width. The heliographic latitude was about eleven degrees north. Between passing clouds on the 17th and 18th of January it was discerned without magnifying power, and in brief views on a screen it was noticeably decreased. The central development was transient, both umbra and penumbra being reduced one half on the morning of the 19th. The eastern half of the disk also displayed evidences of activity, though on a much smaller scale. Hundreds of spots have appeared on the Sun since the minimum in 1902, but this is only the second of enormous extent, the first of the present maximum having occurred in October, 1903.

San Francisco, January 19, 1905.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

DISCOVERY OF A SIXTH SATELLITE TO *JUPITER*.

Part of the programme of work decided upon several years ago for the Crossley reflector when its new mounting should be completed consisted of a search for new satellites about the outer planets.

The first photograph of the region about *Jupiter* was obtained on December 3d and others on the 8th, 9th, and 10th. A comparison of these negatives showed an object of the fourteenth magnitude which was moving with an apparent velocity among the stars not very different from that of *Jupiter*. *Jupiter* was retrograding slowly at that time. The suspected object was to the westward and moving a little faster than the planet. From so short an interval, however, it was not possible to decide whether the object belonged to *Jupiter* or was an asteroid so situated as to be moving with nearly the same apparent speed as the planet.

Observations were secured again on January 2d, 3d, and 4th, which showed the object to be following *Jupiter* in such a way as to indicate its dependence upon that body.

While the observations are not sufficient to determine an accurate orbit of the new body, they are at a favorable part of the orbit for testing its motion about *Jupiter*. A calculation shows that its apparent motion about *Jupiter* during the interval covered by the observations is approximately that which a satellite should have at that distance from *Jupiter*.

Its greatest elongation distance (west) appears to have been about 50′, and to have been passed about December 25th. The plane of its orbit seems to be inclined to the ecliptic at an angle somewhat greater than is the orbit-plane of the inner

* Lick Astronomical Department of the University of California.

satellites. It is apparently moving in the *opposite direction* from the other satellites. Whether this retrograde motion is real or only apparent cannot be told until more observations have been obtained.

Assuming its orbit to be nearly circular, its period of revolution would be about six months. Its real distance from the planet is approximately six million miles, or about five times that of the fourth satellite.

The sixth satellite has been estimated to be of the fourteenth photographic magnitude. Visually, it is probably from one half-a magnitude to a magnitude brighter, or about the same brightness as BARNARD'S fifth satellite.

As soon as sufficient observations have accumulated its orbit will be determined. It is now moving toward the planet about 1′ per day.

The last observation was obtained on January 28th.

January 30, 1905. C. D. PERRINE.

VISUAL OBSERVATION OF SATELLITE VI TO *JUPITER*.

Last Saturday night, January 28, 1905, the first opportunity presented itself to me to look for PERRINE'S satellite to *Jupiter* with the 36-inch refractor. As the telescope had been at the disposal of the regular Saturday-night visitors earlier in the evening, the planet was already low in the sky. The atmospheric conditions also were unfavorable, though the sky was clear. The satellite was picked up easily at the first trial from the position predicted by the Crossley photographs on preceding nights, and in a few minutes' time the motion in Right Ascension made the identification certain.

The satellite was followed for nearly an hour, and the extreme settings showed an hourly motion in Right Ascension of about + 20″, which is in good agreement with the photographic results. No attempt was made to secure an absolute position, as this can be better obtained from the photographic plates.

The bad seeing made magnitude estimates very uncertain, but, from the appearance of faint stars of known brightness, I would say that the satellite is about equal to a fourteenth-magnitude star.

So far as I know, this is the first time the satellite has been

seen with certainty, though Professor HUSSEY on one night early in the month saw an object near the predicted place of the satellite. Clouds interfered before motion could be observed.

R. G. AITKEN.

January 30, 1905.

A LIST OF NINE SPECTROSCOPIC BINARY STARS.

The following nine stars have been determined to be spectroscopic binaries, from observations made with the Mills spectrograph attached to the 36-inch equatorial. As is well known, the presence of an invisible companion in a star of this type is shown by its gravitational influence upon the visible star, causing the latter to revolve in an elliptical orbit around the center of mass of itself and the invisible companion. The velocity of the visible star in the line of sight therefore varies, and the spectrographic determination of the velocities at all points in the orbit enables us to determine the form of the orbit and its position in the orbit-plane. The position of the orbit-plane remains undetermined.

	Discovered by
α *Andromedæ*	HEBER D. CURTIS.
ξ *Ceti*	W. W. CAMPBELL.
γ *Geminorum*	KEIVEN BURNS.
α_2 *Geminorum*	HEBER D. CURTIS.
η *Boötis*	JOSEPH H. MOORE.
ξ *Serpentis*	HEBER D. CURTIS.
ζ *Lyræ*	HEBER D. CURTIS.
τ *Sagittarii*	HEBER D. CURTIS.
71 *Aquilæ*	HEBER D. CURTIS.

α_2 *Geminorum*, the brighter component of *Castor*, is of special interest. Dr. CURTIS has secured about twenty-five plates of its spectrum, from which it appears α_2 and the invisible companion revolve once around in their orbits in approximately 9.27 days. The fainter component of *Castor* (α_1) was discovered to be a spectroscopic binary in 1896, by Dr. BELOPOLSKY, at Pulkowa, Russia, with a period of 2.93 days. The system of *Castor* therefore comprises, so far as known at present, two visible and two invisible stars. Dr. CURTIS is engaged in a study of the entire system, based upon our spectrographic observations. It may be recalled that *Castor* is the double

star first studied systematically by Sir WILLIAM HERSCHEL, and from which he concluded that there are systems of visual binary stars, in which the two components are revolving around their common center of mass.

The number of spectroscopic binaries thus far discovered with the Mills spectrograph, and announced, is fifty-eight, not counting those (five) found by the D. O. Mills Expedition to Chile, nor the three found by Dr. R. H. CURTISS with the one-prism spectrograph. W. W. CAMPBELL.

THE COMETS OF THE YEAR 1904.

Five comets were discovered in the year 1904, two of which were the periodic comets known as Encke's and $Tempel_2$. The former is too near the Sun at present for observation, but it is hoped that further measures may be secured later on.

Of the three unexpected comets of the year, one (Comet *a* 1904) was discovered in America, the other two in Europe. Comet *a* has been described in earlier number of these *Publications*, and it is only necessary to add that it is still well placed for observation, and, judging from two observations made this month with the 12-inch telescope, will remain visible in large telescopes for several months longer.

Comet *d* was discovered by M. GIACOBINI, at Nice, on December 17, 1904. It is very small and faint, and as it is receding both from the Earth and the Sun, will soon become a very difficult object. From my observations of December 19 and 27, 1904, and January 9, 1905. I have computed the following set of elements for this comet:—

$$T = 1904 \text{ November } 3.2272 \text{ Gr. M. T.}$$

$$\left.\begin{aligned} \omega &= 40^\circ\ 42'\ 34''.8 \\ \Omega &= 218\ \ 28\ \ 04\ .5 \\ i &= 99\ \ 36\ \ 41\ .2 \end{aligned}\right\} 1905.0$$

$$\log q = 0.274540$$

Residuals for the middle place (O – C):—

$$\Delta\lambda' \cos\beta' = +3''.3;\ \Delta\beta' = -3''.8$$

The ephemeris, to March 6, 1905, may be found in *L. O. Bulletin*, No. 67.

The last comet of the year was discovered by M. BORRELLY, at Marseilles, on December 28, 1904. It is brighter than

GIACOBINI's comet, but, like the latter, has passed perihelion, and is receding from the Earth. It is not likely, therefore, to remain visible very long.

R. G. AITKEN.

January 24, 1905.

NOTE ON TWO INTERESTING BINARIES IN *CETUS*.

The star *Ceti* 82, was found to be a close double star by BURNHAM in 1875, but no accurate measures were made until 1886. The observed motion in the next five years was very slow, but that the pair would ultimately prove to be an interesting physical system was evident from the large proper motion common to the two components—about 1".4 annually in the direction 90°.

The star was not observed from 1891 to 1897, but in the latter year SEE measured it and found a remarkable change.

The companion-star was now in the fourth quadrant instead of the second, and less than half as far from its primary as in 1891. Dr. SEE computed an orbit and found a period of only 16.3 years, but the observational data were at that time insufficient for accurate conclusions, and later measures have indicated a very different orbit. I have followed this pair regularly since 1897, and with the aid of the additional data thus secured have now computed an orbit which will, I hope, at least approximate the truth. The details of this computation will be printed as one of the *Bulletins* of the Lick Observatory; it will therefore be sufficient here to give the mean of my most recent observations and the elements of the computed orbit. The mean of two measures in December is:—

1904.96 332°.8 0".20

And the elements are:—

$P = 24.0$ years	$\Omega = 110°.8$
$T = 1899.7$	$\omega = 159.4$
$e = 0.15$	$i = \pm 76.65$
$a = 0''.66$	$\mu = + 15.00$

Apparent motion direct.

Another interesting binary in this constellation is 13 *Ceti*. This star has had a peculiar history. In 1877 BURNHAM catalogued a distant companion, but saw nothing unusual about the bright star. In 1886, however, HOUGH, with the same tele-

scope, found the bright star to be a close double. He also secured one measure in the following year. In 1890 and 1891 the star appeared round to BURNHAM when he examined it with the 36-inch telescope under good conditions, but in 1899 SEE found it an easy pair to measure with the 26-inch at Washington, and I have measured it every year since then with the 36-inch telescope. My last measures give:—

1904.96 $12°.8$ $0''.12$ 2^n

The companion has apparently described an arc of nearly 300° since its discovery by HOUGH in 1886, and it is evident that the revolution period will be very short—certainly less than twenty-five years. It would not be difficult to construct an orbit that would represent all the observations so far made and that would also satisfy the condition that the apparent separation of the two components must be assumed to be very small in 1877 and in 1890 and 1891, when BURNHAM failed to see the star double. Such an orbit would probably define the revolution period, the inclination, and some of the other elements with a fair degree of accuracy, but others, and especially the eccentricity, would be very uncertain, depending almost wholly on HOUGH's estimates (not measures) of distance on two nights only. It will be more satisfactory to wait a few years until further measures have supplied data for an accurate orbit.

R. G. AITKEN.

January 25, 1905.

NORMAL PLACES OF THE *EROS* REFERENCE-STARS.

Since the inauguration of the work of determining the solar parallax from observations upon the planet *Eros*, the discussions in current astronomical literature as to the proper combination and use of observations have been very extensive. Not the least among the points of controversy has been the proper use of the meridian-circle observations employed.

To those who have been noting the progress of the *Eros* work it will be a source of gratification to learn that the stars observed by the meridian-circle have been reduced to a normal system which will be used without further discussion by those employed on the *Eros* work. The catalogue of the normal places is published in Circular No. 11 of the Conférence Pho-

tographique Internationale. The reduction was made by Mr. R. H. TUCKER, of the Lick Observatory, and a brief outline of the method employed is here given. The two lists of *Eros* stars were observed with greater or less completeness at thirteen widely-separated observatories, the names of which are given in a table at the end of this article. As was anticipated, small systematic differences were found in the resulting star places as published by the separate observatories, and it has been the aim of Mr. TUCKER, in the above publication, so to combine the separate results as to obtain the most probable value of the definite position of each star.

As is well known, these stars are to be used to obtain the positions of *Eros,* from the plates upon which it has been photographed. If the field of the photograph is large enough to include a sufficient number of these stars for determining the plate constants and scale value, the position of *Eros* may be at once derived. But if the field is small, and there are but few if any of these reference-stars found upon it, recourse must be had to the fainter stars which it contains. The positions of these faint stars are derived from photographs taken for the purpose, containing the faint stars and stars of the present normal system to be used as reference-points.

The first step in the reduction was to find the difference in Right Ascension and Declination between each star of the Lick Observatory list and the Right Ascension and Declination of the same star as given in each of the other lists. Any complete list would have served the same purpose; but the Lick Observatory list has been chosen on account of its uniformity and completeness. The resulting comparison gave twelve series of results, each containing as many differences as there were stars common to the two lists compared. As every star of the *Eros* lists was observed at the Lick Observatory, all the material that each list furnishes for deriving suitable corrections to reduce to a normal system is contained in these twelve series.

The mean of each series of residuals is now taken. These mean differences represent the corrections which must be applied to each list in order to reduce them to the Lick Observatory system. To derive the correction which must be applied to the Lick Observatory list the weighted mean of the twelve mean differences, indicated above, is taken with contrary sign.

This correction to Lick Observatory is applied to each mean difference, and the result is the correction for each list, necessary to reduce it to the weighted mean of all the lists.

The range in Right Ascension of the first list is small, and there is no evidence of a rate in the Right Ascension or Declination corrections corresponding to a change in Right Ascension. The range in Declination is comparatively large, however, and an investigation was made of the rate in the Right Ascension and Declination corrections, corresponding to changes in Declination. Thirty stars of the lowest Declination ($38°.1$ to $41°.3$) and thirty of the highest ($54°.1$ to $55°.4$) have been separately compared, for deriving the rates for the first list. Since the groups thus compared differ less than five minutes in Right Ascension, the rates derived should be mainly due to the Declination factor. The corrections derived in the manner indicated above, together with the rates here obtained for them, are tabulated in tables IV and V of the publication.

These corrections having been applied to the coordinates of the respective lists, the weighted mean of the Right Ascension and Declination as furnished by these corrected lists is taken. This weighted mean furnishes the final definitive position as published in the catalogue.

In the first list there are in Right Ascension about 8,500 observations included; in Declination about 7,000, giving an average per star of 26 and 22 respectively. In the second list there are 10,640 observations in Right Ascension, and 9,140 in Declination, giving averages respectively of 30 and 26 per star.

The probable error of the separate determinations have been computed from the residuals of the corrected results, compared with the weighted mean. For weight unity the probable errors are found to be $\pm 0^s.045$ and $\pm 0''.38$ in the first *Eros* list. Since the total of the weights assigned would give an average of 22 per star in Right Ascension and 19 in Declination, the probable errors of the catalogue place would be $\pm 0^s.009$ and $\pm 0''.09$ respectively. In the second list, for the average weight, the probable errors of a place are found to be $\pm 0^s.007$ and $\pm 0''.09$.

Preceding each of the two lists is a table giving the probable errors of the separate determinations, by observatories, together

with the average number of observations upon which a determination depends. The probable error of a final position, as given above, will be the only one with which those who use these stars will be concerned. It is a source of no little interest, however, to see a comparative statement of the probable error of a single observation, as made at the separate observatories.

From a well-known least-square theorem, the probable error of one determination is obtained by dividing the probable error of the mean of several by the square root of the number included in the mean. Using this method, I have obtained from these tables the probable error of one observation for each observatory in the list. Each of the two tables will give a determination; and below is given the mean probable error of one observation, as determined from the two tables, the Right Ascension error being first transformed into seconds of arc.

	R. A.	Decl.
Abaddia (Italy)	$\pm 0''.40$	$\pm 0''.41$
Greenwich	.57	.45
Kœnigsberg	.51	..
Lick	.31	.28
Lisbon	.34	.35
Marseilles	.69	.42
Nice	.57	.43
Paris	.60	.47
Rome	.97	.88
San Fernando (Spain).	.84	.56
Strassburg	.33	.40
Toulouse	.57	.36
Washington	.43	.55

The Kœnigsberg Right Ascensions and Declinations were observed separately and the observations in Declination have not yet been published.

The probable error as given for Rome depends upon the first list, only a small number of stars of the second list having been observed there.

The two lists were observed at Washington with different instruments. The observations in Declination made with the old instrument are found to be more accurate and reliable than those made with the new one.

ELLIOTT SMITH.

January, 1905.

ADDITIONS TO THE LICK OBSERVATORY RESERVATION.

The Regents of the University of California have recently added to the Lick Observatory Reservation, by purchase, two hundred and forty acres of land, as follows:—

Eighty acres near the northeast corner of the Reservation (Holden tract); one hundred and sixty acres on the western edge of the Reservation, one hundred and twenty acres of which projected within the general western boundary-line (Cook tract).

The Reservation has been formed, as follows:—

By Congressional Grant (original)....	1345.80 acres
By Congressional Grant (second).....	599.94
By California State Grant...........	320
By Gift, ROBERT F. MORROW..........	40
By Purchase	191.49
By Purchase	40
By Purchase	80
By Purchase	160
Total	2777.23 acres

W. W. CAMPBELL.

GENERAL NOTES.

The *Astrophysical Journal* for January, 1905, contains an interesting article, by Professor BARNARD, on the Bruce photographic telescope of the Yerkes Observatory. This instrument has been in the course of construction for a number of years, and was finally completed and put into position during April, 1904. It is a doublet, both lenses being of the "portrait-lens" type. The larger of the two lenses has an aperture of ten inches and a focal length of fifty inches, the smaller an aperture of six and a quarter inches and a focal length of thirty-one inches. As will be seen from the shortness of the focus of these lenses, they are well adapted to photographing such objects as comets, portions of the Milky Way, and parts of the sky containing faint nebulous masses. Two excellent reproductions of the Milky Way in *Cepheus* are given to illustrate the work of these lenses. The larger lens was figured by BRASHEAR, and the mounting for the lenses was made by WARNER & SWASEY. The mounting contains a number of novel features, chief of which is the bending of the iron pier through such an angle as to make the upper part of it serve as the polar axis of the instrument. By this device it is possible to carry the telescope past the meridian without bumping into the pier, and this is very useful when photographing an object which crosses the meridian near the middle of a long exposure. The pier is constructed of two parts, so that the inclination of the upper part may be changed to any desired angle by the insertion of a wedge of the proper size. The clockwork is provided with a device by which its motion may be reversed so the instrument may be used in the southern hemisphere if desired. The instrument has been dismounted and transported to Southern California, where it is to be used for some time to photograph portions of the Milky Way which cannot be reached at the more northern latitude of the Yerkes Observatory. We may feel sure that some excellent astronomical pictures will be secured while the instrument is in the hands of such an experienced astronomer and photographer as Professor BARNARD. S. D. T.

On the evening of December 15, 1904, a lunar fog-bow was seen at this observatory. The moon at the time was about five

degrees above the crest of the mountains to the west, and some twenty degrees above the horizon. The valley was filling with fog, and the bow was seen distinctly against the fog covering the eastern mountains. The bow was complete, but the separate colors were not distinguishable. The phenomenon remained visible for several minutes, and on the following evening another, but fainter, bow was seen under almost exactly similar conditions. S. D. T.

INTERNATIONAL LATITUDE OBSERVATORY, UKIAH, CAL.

The annual report of the meteorological observations made at the International Latitude Observatory of Mizusawa (Japan) has been issued recently. In many respects the weather of Japan is almost the exact antithesis of that of California, and it is of interest to compare the weather at the two stations, Mizusawa and Ukiah, for 1903. I am indebted to Dr. GEORGE McCOWAN, volunteer observer of the U. S. Weather Bureau, for the meteorological data of Ukiah. In the U. S. Weather Bureau service "clear days" are defined as those in which the average cloudiness is less than three on a scale of ten, and "cloudy days" those on which the average is greater than seven. No statement is made in the report concerning the Japanese practice in this regard. During 1903 there were sixteen days upon which a sprinkle of rain fell at Ukiah, and these are classed with the days upon which no rain fell.

	MIZUSAWA.	UKIAH.
Precipitation (1903)	63.10 inches.	32.40 inches.
Maximum	8.83 (Aug.)	11.93 (Nov.)
Minimum	1.46 (Feb.)	0.00 (May, June, July, Aug., Sept.)
Number of days on which rain fell	238	60
Number of days on which no rain fell	127	305
Maximum interval with rain every day	July 16 - Aug. 4 (20 days.)	Jan. 19 - Jan. 28 (10 days.)
Maximum interval without rain	Apr. 3 - Apr. 10 (8 days.)	Apr. 17 - Oct. 3 (170 days.)
Number of clear days	17	227
Number of cloudy days	189	67
Maximum temperature	93° F. (Sept.)	111° F. (Aug.)
Minimum temperature	5° (Dec.)	19° (Feb.)

The report contains also, as an appendix, a list of the earthquakes experienced at Mizusawa in 1902 and 1903. In the former year there were 155 and in the latter 114, besides a considerable number of pulsatory oscillations. S. D. T.

The *Astrophysical Journal* for December, 1904, contains some very interesting articles, most of which were read before the Congress of Arts and Sciences which met in St. Louis in September. Our readers who are interested in spectroscopic work should not fail to obtain a copy of this number of the *Journal*. A list of the articles referred to is given below: "Co-operation in Solar Research," GEORGE E. HALE; "Remarks on Standard Wave-Lengths," HENRY CREW; "Rapport sur la Nécessité d'établir un Nouveau Système de Longueurs d'Ondes Etalons," A. PÉROT et CH. FABRY; "New Standards of Wave-Length," H. KAYSER; "Some Total Solar Eclipse Problems," C. D. PERRINE; "On a New Method for the Measurement of Stellar Spectra," J. HARTMANN; "A Desideratum in Spectrology," EDWIN B. FROST.

Last night a most wonderful fireball was seen at this station. While walking around outside the observatory "between stars" of the latitude observing programme, a fireball of the shape of the crescent Moon appeared suddenly in the southeast, moved slowly to the north in a horizontal plane about on the almucantar of the Pole Star. As the object moved it developed rapidly, passing through phases like the Moon until the full-moon stage was reached. After remaining at this maximum size a moment, this remarkable object then passed rapidly through the phases of the waning Moon, and finally disappeared about ten degrees east of the Pole Star. When full the fireball was somewhat larger than the full Moon,—perhaps about 37′ in diameter,—but not quite so bright as the Moon. When in the crescent form, just before disappearance, the whole disk was seen faintly appearing like the new Moon when lit up by the earth-shine. Immediately after the disappearance of this remarkable fireball I went into the observatory to record the time, which was found to be 1^{h} 40^{m}, and then I

awoke with a dull, sickening thud and found that it was quarter past seven and time to get up and light the fire. S. D. T.

UKIAH, CAL., December 7, 1904.

The International Jury at St. Louis awarded a gold medal to Professor BROOKS. of Hobart College, for the discovery of comets. Dr. BROOKS now has twenty-four to his credit.

The Lalande gold medal of the French Academy of Sciences has been awarded to Professor S. W. BURNHAM, of the Yerkes Observatory, for his researches in astronomy.

MISS DOBBIN'S DETERMINATION OF THE ORBIT OF THE FIFTH SATELLITE OF *JUPITER*.

I am quite unable to understand Mr. TOWNLEY's criticism of Miss DOBBIN's work on the fifth satellite of *Jupiter* in *Publications* A. S. P., No. 98 (page 223).

It was at my suggestion entirely that she based her work upon my observations alone—not that those observations were supposed to be better than any others, but for one reason in particular, and that the one Mr. TOWNLEY objects to,—viz., that they were all made by one observer, which would prevent any confusion that might come from the personality of different observers by which the very quantities sought might be masked. And further, the only measures that have been made of this satellite are those at the Lick, at the Pulkowa, and at the Yerkes observatories. No measures have been published from Pulkowa in ten years that I know of, and I am under the impression that no measures have been made there in that time. Professor AITKEN's valuable measures are referred to the other satellites, and would require an investigation of their orbits before they are available. Furthermore, as these observations were made by an entirely different method, they should be treated differently, and when this has been done they will give an independent determination of the orbit which will have peculiar values of its own. As Miss DOBBIN was forced from want of time to confine herself to recent years, she had no choice in the matter for the very want of other material.

Mr. TOWNLEY cites the admirable work of Mr. HINKS in the determination of the solar parallax from photographic

observations made at different observatories in America and Europe as an example of using the work of different observatories. This illustration does not seem to be a just one, for the two cases are quite different, and for the reason also that the parallax depended on different observers placed at different points on the Earth's surface, and was in strict adherence to a definite programme previously arranged for; though it is true that one observer could have determined the parallax from morning and evening observations, as was done by Sir DAVID GILL in 1877 with *Mars*. The uncertainty of getting complete sets of observations for the evening and morning observations from one point made the plan followed by Mr. HINKS the better one. It will be noticed, however, that Mr. HINKS shows that even in this case the other method would have been justified by the remarkable agreement of GILL's individual heliometer results from minor planets with the more elaborate results from *Eros*. The probable errors of the two were almost identical.

As an example of using the work of one observer in the determination of an orbit, I would refer to the *Astronomical Journal* (Nos. 236, 237), where, determining the orbits of the companions to Comet V 1889, Dr. CHANDLER finally made a complete investigation of their orbits by using alone my observations of these bodies made with the 36-inch of the Lick Observatory, and this after having used all the observations that had been made of these companions at the Lick and elsewhere.

In the same journal (*A. J.*, 441) Professor ASAPH HALL made an investigation of the orbit of the satellite of *Neptune*, using only my observations made with the 40-inch here. At the same time there were plenty of other observations to be had. In closing his paper, Professor HALL says: "Each observer, however, should make a complete and careful series of measures as Professor BARNARD has done, since sporadic observations are of little use."

From the examples set by these eminent men, Miss DOBBIN was justified in her method of treating the observations of the fifth satellite of *Jupiter*, even though there had been an abundance of other measures, which there was not.

YERKES OBSERVATORY, November, 1904. E. E. BARNARD.

Minutes of the Meeting of the Board of Directors, held in the Rooms of the Society, January 28, 1905, at 7:30 P.M.

President Edwards presided. A quorum was present. The minutes of the last meeting were approved.

The following members were duly elected:—

List of Members Elected January 28, 1905.

Mr. Ferdinand Ellerman . . .	Solar Observatory, Mount Wilson, via Pasadena, Cal.
Prof. George E. Hale . . . . . Foreign Assoc. R.A.S.	Director of the Solar Observatory, Mount Wilson, via Pasadena, Cal.
Dr. A. Lilienczrantz	359 Telegraph Ave., Oakland, Cal.
Mr. George W. Ritchey . . . . Foreign Assoc. R.A.S.	Solar Observatory, Mount Wilson, via Pasadena, Cal.
Mr. E. C. Smith	Saint Albans, Vermont.
Wellesley College Library . . .	Wellesley, Massachusetts.
Mrs. Elsie Hadley White . . .	The Executive Mansion, Bismarck, North Dakota.

It was, on motion,

Resolved, That the proposition to amend Article II of the By-Laws be referred to a committee of two, consisting of Messrs. Aitken and Townley, for investigation.

Resolved, That the Solar Observatory, Mount Wilson, via Pasadena, Cal., be placed on the list of Corresponding Institutions.

Resolved, That the suggestion of changing the class headings of departments of publication be referred to the Publication Committee, with power to act.

A committee to nominate a list of eleven Directors and Committee on Publication, to be voted for at the annual meeting, to be held on March 25th, was appointed as follows: Messrs. A. H. Babcock (Chairman), R. T. Crawford, J. K. Moffitt, J. D. Galloway, Wm. Grant.

A committee to audit the accounts of the Treasurer, and to report at the annual meeting in March, was appointed as follows: Messrs. Chas. S. Cushing (Chairman), A. O. Leuschner, D. Suter.

William Alvord died at his home in San Francisco, on December 21, 1904.

Mr. Alvord was one of the many friends which it has been the good fortune of this Society to possess. From the very beginning of the Society he gave his energetic support in procuring a large number of its members, of whom he was the first to become a life member; he was a member of the Board of Directors and one of its Presidents. He

was ready to give financial aid when needed, and by his last will and testament has made a large bequest to the Society. For the last sixteen years of his active and honorable career he was President of the Bank of California.

The following resolutions were adopted:—

WHEREAS, WILLIAM ALVORD, one of the most prominent citizens of San Francisco, and an ex-President of this Society, died on the twenty-first day of December, 1904;

Resolved, That in the life of WILLIAM ALVORD we recognize the best type of the American citizen, ever ready to give his services and assistance to his fellow-man;

Resolved, That in his death the body politic generally, and this Society particularly has sustained a loss they can ill afford.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. GEO. C. EDWARDS . . . . *President*
Mr. S. D. TOWNLEY . . . . *First Vice-President*
Mr. CHAS. S. CUSHING . . . . *Second Vice-President*
Mr. A. O. LEUSCHNER . . . . *Third Vice-President*
Mr. R. G. AITKEN }
Mr. F. R. ZIEL } . . . . *Secretaries*
Mr. F. R. ZIEL . . . . *Treasurer*

Board of Directors—Messrs. AITKEN, BURCKHALTER, CAMPBELL, CROCKER, CUSHING, EDWARDS, LEUSCHNER, MILLER, PARDEE, TOWNLEY, ZIEL.
Finance Committee—Messrs. CUSHING, LEUSCHNER, ——.
Committee on Publication—Messrs AITKEN, SCHLESINGER, TOWNLEY.
Library Committee—Messrs. TOWNLEY, BABCOCK, Miss O'HALLORAN.
Committee on the Comet-Medal—Messrs. CAMPBELL (*ex-officio*), CROCKER, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. RUTHVEN W. PIKE.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. FELIPE VALLE.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
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PUBLICATIONS

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VOL. XVII. SAN FRANCISCO, CALIFORNIA, APRIL 10, 1905. NO. 101.

THE DEVELOPMENT OF A NEW OBSERVATORY.

By GEORGE E. HALE.

The editor of the *Popular Science Monthly*, in the last issue of that journal, questions the wisdom of the Carnegie Institution in transferring a portion of the staff of the Yerkes Observatory to California for the purpose of establishing a new observatory. He believes that observatories should be situated where the seeing is best, and that good results may be obtained on Mt. Wilson, but doubts the necessity of providing for more astronomical work in a region already so well represented by the Lick Observatory.

The criticism, which is made in perfect fairness, is doubtless one that will independently present itself to others. It deserves an answer, which I shall endeavor in this paper to supply.

Let me say at the very outset that we yield to no one in our admiration for the splendidly effective work of our good friends on Mt. Hamilton. If it had been a question of duplicating the work of the Lick Observatory, or of occupying a similar field, the Solar Observatory would not have been founded.

It is easy to believe that one who has but recently closed a long period of preparation, which involved not only the ordinary discomforts of building, but also the details of construction of an extensive instrumental equipment, would not lightly embark upon another similar enterprise. A mountain summit, reached only by a narrow trail, and with no immediate prospect of better means of approach, does not appear to one engaged in quiet research as an ideal place for building operations. Furthermore, the great Yerkes telescope, thoroughly tested by investigations in many fields, appeals more

and more strongly to the imagination as one's acquaintance with its capabilities increases. The possibilities of research which this instrument affords are unlimited. In some departments they are almost unique. Certain solar phenomena, for example, which it is one of the principal purposes of the new Solar Observatory to study, have hitherto been recorded only with the Yerkes telescope. The atmospheric conditions at Lake Geneva are not of the best, but with reasonable patience the astronomer finds enough good days in the year to crowd his cabinet with negatives that will repay much careful measurement and study. With these opportunities within his grasp, the attraction must indeed be a powerful one that will lead a reasonable man into new and uncertain fields.

But there is another side to the shield—a side so bright with promise that a few more years of preparation, even though they may temporarily deny the opportunity for research, may be considered as a slight obstacle. A man of science must so direct his efforts as to secure the largest results not within a single month or a single year, but within the entire period of his activities. He can thus afford to devote much time and effort to details of construction, if these promise sufficient advantage in the end. He must work for years, if need be, to secure such means of investigation as appear to him needful.

The purpose of the Solar Observatory should now be stated. It is not intended, in any important feature, to duplicate the work of the Lick or the Yerkes observatories. The aim of the Solar Observatory will be to apply new methods of research, under remarkably favorable atmospheric conditions, in a study of the constitution of the Sun and the problem of stellar evolution. The apparatus and methods, for the most part, will differ decidedly from those employed elsewhere. With its large shop, equipped for the construction of both the mechanical and the optical parts of instruments, the Solar Observatory will be in a position to develop new apparatus as fast as the need for it appears.

The proposed methods of research will cause the new institution to resemble a physical laboratory more closely than an observatory. For years astronomers have recognized some of the advantages that must result from a realization of laboratory conditions in observatory practice. Indeed, tele-

scopes have been constructed that might seem on casual examination to accomplish the very purpose here in view. But an acquaintance with the facts would show that these telescopes, though they in some cases form stellar or solar images within laboratories, are suited for only a small part of the investigations now contemplated. Some of these, like the great equatorial *coudé* of the Paris Observatory, have splendidly demonstrated their worth in other fields of research. But even this instrument would be unsuited for our needs.

What we must have, if the full possibilities of solar research with the spectrograph and spectroheliograph are to be realized in practice, is a telescope of such mechanical and optical design, linear dimensions, and geographical position as to permit the formation of a sharply defined solar image, from fifteen to twenty inches in diameter, within a suitably equipped laboratory, on a large number of days in the year. These conditions have never been attained or even approached in practice, and no existing observatory is in a position to provide them.

So far, reference has been made only to the type of telescope required for solar investigations. The telescope is usually regarded as the principal instrument of the astronomer, and it is of course absolutely indispensable. Nevertheless, it may fairly be said that in the present state of solar research the spectroscopes and other instruments used in conjunction with the telescope are no less important than the telescope itself. The equatorial refracting telescope, hitherto employed almost exclusively in solar and stellar spectroscopy, has, through the nature of its construction, hindered the free development of the astronomical spectroscope. The serious effect of the changing temperature in an open dome, especially on the optical properties of prisms, has been recognized in recent stellar spectrographic work, and effective devices have been employed to maintain the temperature of the prisms constant throughout an exposure. But the limitation of size, imposed by the necessity of attaching spectroscopes to a moving telescope-tube, cannot so easily be overcome. This has precluded the use of long-focus grating spectroscopes, such as ROWLAND employed in his researches on the solar spectrum. Spectroscopes of this type are common enough in physical laboratories, and the classic results of ROWLAND, to speak of no other work,

show how successfully they have been applied in investigations of the Sun. But whereas the astrophysicist has almost invariably been confined to the employment of small spectroscopes, which could easily be adapted to moving telescopes, the physicist has used powerful spectroscopes, properly mounted on piers, but provided with no adequate means of forming the image of a celestial body upon the slit. For this reason ROWLAND's work was confined to the study of a very small solar image, produced with the aid of an ordinary laboratory heliostat. He was thus unable to investigate various minute phenomena of the Sun's surface, which can be observed only in large solar images produced by powerful telescopes. On the other hand, the users of such telescopes have had at their disposal no spectroscopic apparatus adequate for solar and stellar researches equivalent in precision to ROWLAND's investigations.

In making these remarks I do not wish to be understood as in any way criticising the magnificent work hitherto accomplished by investigators in solar and stellar spectroscopy. Nothing could be more successful, for example, than the epoch-making determinations of stellar velocities in the line of sight perfected by CAMPBELL at the Lick Observatory, and it will be many years before a degree of precision in the measurement of the solar spectrum appreciably higher than that attained by ROWLAND and JEWELL at the Johns Hopkins University will be realized elsewhere. In both lines of investigation the available means of research have been utilized with extraordinary success. It is only through the lack of proper instruments that such special researches as we desire to undertake at the new Solar Observatory have not been carried out. In stellar spectroscopy these special studies will not in any way compete with the work now being accomplished by CAMPBELL, FROST, and others. They will simply permit the use of much higher dispersion for the minute investigation of the spectra of some of the brighter stars. In solar spectroscopy, on the other hand, while the degree of precision attained in previous investigations will hardly be exceeded, it is hoped that these investigations may be extended from the general light of the Sun to the details of solar phenomena.

To accomplish such results should be a comparatively easy matter as soon as a large and well-defined solar image or a

brilliant and sharply defined stellar image can be produced within a laboratory. Spectroscopes may then be rigidly attached to immovable piers; the temperature conditions, when this is desirable, may be controlled more perfectly than is possible within an open dome; and the limitations of size, which are so evident in the case of an equatorial telescope, will no longer exist. In other words, the spectroscope, instead of occupying the position of an attachment to a telescope, may take its place as an instrument of still greater power and possibilities. From this point of view, it would hardly be unreasonable to define a telescope as an instrument for forming the image of a heavenly body on the slit of a spectroscope.

The importance of such an advance has been constantly before my mind for years. In the earliest work of the Kenwood Observatory, before the development of the spectroheliograph had been undertaken, this plan had already presented itself to me, as it doubtless had to others. Constant use of a long-focus concave grating in the study of the solar spectrum had strongly impressed me with the beauty and power of this instrument and the immense possibilities it would offer if, in modified form, it could be applied to the study of a large solar image. Subsequently, when engaged in the investigation of stellar spectra with a three-prism spectrograph, the dispersion of such an instrument seemed small and unsatisfactory when compared with that of a powerful grating spectroscope. Indeed, in passing from one instrument to the other it seemed almost like returning from the era of spectroscopy inaugurated by ROWLAND to the period of KIRCHHOFF and BUNSEN. I do not mean that the great possibilities of the prism spectrograph were underrated. Such an instrument to-day is by no means to be compared with the apparatus of the earlier investigators, particularly in view of the great extension of its power rendered possible by the application of photography. Spectrographs of this character will occupy an important place in the equipment of the Solar Observatory, and I do not believe that they can be materially improved in design as compared with the Mills spectrograph of the Lick Observatory or the Bruce spectrograph of the Yerkes Observatory. But the recognition of these facts cannot prevent one whose work has been largely dependent upon the use of long-focus grating spectroscopes

from feeling that the realization of similar resolving powers in stellar spectroscopic research is a desideratum of the highest importance. In the Solar Observatory it is hoped to accomplish this result, at least for a few of the brightest stars, through the provision of a *coudé* mounting for a five-foot reflecting telescope, and the use of a large-grating spectrograph, mounted on a massive pier in a constant-temperature laboratory, where exposures long enough to record the feeble light of the star when highly dispersed can be given without fear of disturbance arising from flexure or temperature change.

The development of the spectroheliograph furnished another strong incentive toward the accomplishment of such changes in telescope design as are here in view. When the Rumford spectroheliograph was first undertaken, the unsuitability of such a telescope as the 40-inch Yerkes refractor for work with so heavy an attachment was strongly realized. A spectroheliograph of these dimensions should be capable of motion as a whole across the focal plane of the telescope. In spite of the great strength and rigidity of the steel tube of the telescope, which is sixty-four feet in length, the motion of such a mass, weighing about seven hundred pounds, would set the tube into vibration and destroy the possibility of obtaining a sharply defined image. I was accordingly compelled to adopt a type of construction which did not appeal to me from a mechanical standpoint, though it subsequently yielded good results. The motion of the solar image across the first slit of the spectroheliograph was produced by means of an electric motor, which caused the entire telescope-tube to move slowly in declination. The corresponding motion of the photographic plate across the second slit was produced by the same motor, through a shaft led down from the center of the telescope-tube to the eye-end. Such an arrangement, it is obvious enough, is crude and unsatisfactory as compared with a device permitting the motion of the spectroheliograph as a whole, the solar image and photographic plate being fixed in position. On Mt. Wilson a spectroheliograph similar to the Rumford spectroheliograph, but much larger and more powerful, will be mounted on steel balls, so as to move as a whole across the solar image, the friction being relieved to any desired degree by floating the entire instrument in a bath of mercury.

Later developments of spectroheliograph design made it appear necessary to give the instrument much greater focal lengths, in order to secure sufficient linear dispersion. It is essential, if the instrument is to be used successfully in photographing the Sun's disk through the narrow dark lines of the solar spectrum, that these lines should be sufficiently widened by dispersion to cover completely the second slit. For this reason a spectroheliograph thirty-five feet long is to be used on Mt. Wilson. It is obvious that such an instrument could not be attached to an equatorial telescope, for even if its weight could be carried, the flexure of the parts would prove an insuperable obstacle. With a cœlostat reflecting telescope a spectroheliograph of this kind can be mounted rigidly on piers in a horizontal or nearly horizontal position. On account of its great length it will not be moved as a whole, but the motion of the solar image will be produced by the slow rotation of the concave mirror of the cœlostat telescope about a vertical axis.

The optical needs which have become apparent in the development of the spectroheliograph are not confined to that instrument alone. They involve the production of a solar image of a diameter so great that the details of sun-spots and other phenomena may become of appreciable size upon the photographic plate. It is my hope that sun-spots may be photographed with the aid of the widened lines, in such a way as to give a picture showing the distribution within the spot itself of the elements which give rise to these lines. A telescope 145 feet in length is thus rendered desirable. Obviously, even if an equatorial telescope could be made to carry a spectroheliograph thirty-five feet long, it could hardly be given a focal length of 145 feet.

These are some of the considerations that have for years been forcing upon me the immense importance of some form of horizontal telescope. They led me to include a long heliostat room in the design of the Yerkes Observatory, and to prepare, in the first years of the observatory's existence, for the construction of a large heliostat and cœlostat for work there. But the necessity of building in the observatory shop the entire instrumental equipment required for use with the Yerkes refractor, together with other instruments for the observatory, delayed the construction of the apparatus. The heliostat used

solar phenomena, there would be reason enough for every effort put forth to acquire it. But such knowledge is capable of far wider use. Leaving aside the important question as to the relationship between solar and terrestrial phenomena, which is in itself worthy of great consideration, we may consider only the application of knowledge derived from a study of the Sun to the solution of the problem of stellar evolution. Within the wide boundaries of astrophysics there is no problem that appeals to the imagination more strongly than this. It should be obvious enough that if we are to form a correct estimate of the processes of stellar evolution, in which the successive steps in the development of stars from nebulæ are to be definitely stated and understood, we can do so only through an intimate acquaintance with the phenomena of a typical star. No star other than the Sun is sufficiently near the Earth to permit such knowledge to be gained. Reduced by distance to mere points of light, even in the most powerful telescopes, stars of the sidereal system appear to be wholly beyond the reach of detailed examination. We may analyze their light as a whole, but we can study their surface phenomena only by inference, and not by direct observation. The Sun, on the other hand, presents, under excellent atmospheric conditions, a large and sharply defined image for minute study. Here, if anywhere, we may seek with reasonable hope of success for a firm foundation upon which the superstructure of stellar evolution may be erected.

But if these remarks in any way illustrate the importance of the most searching investigation of the Sun, they can hardly fail to suggest the desirability of carrying on simultaneously an investigation of various questions relating to the constitution of the stars. The interdependence of solar and stellar phenomena render it exceedingly desirable that the same investigator should concern himself with both. A study of the various classes of stellar spectra affords the means of tracing out the past and future conditions of the Sun. Hitherto, as already remarked, such investigations have been confined to the use of spectrographs of comparatively small dispersion. Given sufficient light and a powerful grating spectrograph rigidly mounted within a constant temperature room, there is reason to hope that the spectra of some of the brighter stars

may be photographed on a scale comparable with the scale of the solar spectrum in the largest modern spectroscopes. It is accordingly a matter of great satisfaction to state that the five-foot mirror, which was for some time under construction at the Yerkes Observatory by Professor RITCHEY, will be mounted at the Solar Observatory.[1] Funds for the mounting and dome required for this mirror never became available at the Yerkes Observatory, and for several years no work has been done upon it. It will now be finished and erected on Mt. Wilson as soon as possible.

In addition to its use in a study of stellar spectra under very high dispersion by Mr. ADAMS and myself, this instrument will be employed by Professor RITCHEY in photographing the minute details in the structure of the nebulæ, an investigation which he has had constantly in view for many years; by Professor NICHOLS in a continuation of his interesting work on the heat radiation of the stars with the radiometer; and for other similar researches bearing upon the problem of stellar evolution. The massive mounting which Professor RITCHEY has designed for the five-foot mirror, and the success he has already achieved in the photography of nebulæ with the two-foot reflector constructed at the Yerkes Observatory, give reason to hope that the five-foot reflector will accomplish important results in direct photography, especially as the fine night-seeing at Mt. Wilson is accompanied by but little wind.

It is not my intention to claim that the purpose of the Solar Observatory is to be accomplished at once or without difficulty. The cœlostat reflector, through the distortion of its mirrors by the Sun's heat and through other difficulties peculiar to this type of instrument, is hardly likely to give the best results without much study and experience. It is not improbable that some material other than glass must ultimately be used for the mirrors, and that special precautions, not yet worked out, will be necessary in other directions. The work has gone far enough, however, to lead me to hope that the principal objects in view may sooner or later be attained. That the five-foot reflector offers problems of its own may also be admitted, though

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[1] See Professor RITCHEY's account of the construction of this mirror in *Smithsonian Contributions to Knowledge*, Vol. XXXIV.

without serious fear that they cannot be overcome. It is likely enough, for example, that the block of glass five feet in diameter and eight inches thick which forms the mirror of this telescope must be maintained throughout the day at the mean temperature of the night in case its full possibilities are to be realized in practice. But this is a simple matter, requiring only the application of processes commonly employed in commerce. As for the mechanical questions involved in the production of a mounting capable of carrying this mirror with precision, there seems to be no reason to doubt that they can be solved.

I trust it has been shown that the Carnegie Institution, in establishing a Solar Observatory on Mt. Wilson, is entering a new and promising field of research, in which equipment and conditions not now available are indispensable. I am not qualified to express an opinion whether the work to be undertaken is more or less important than possible researches in other departments of science.

MT. WILSON, March, 1905.

PLANETARY PHENOMENA FOR MAY AND JUNE, 1905.

BY MALCOLM MCNEILL.

PHASES OF THE MOON, PACIFIC TIME.

New Moon,	May	4,	$7^h\ 50^m$ A.M.	New Moon,	June	2,	$9^h\ 57^m$ P.M.
First Quarter,	"	11,	10 46 P.M.	First Quarter,	"	10,	5 5 A.M.
Full Moon,	"	18,	1 36 P.M.	Full Moon,	"	16,	9 51 P.M.
Last Quarter,	"	25,	6 50 P.M.	Last Quarter,	"	24,	11 46 A.M.

The Sun reaches the summer solstice and begins his southward motion at about 7 P.M. June 21st, Pacific time.

Mercury will not be in very good position for observation during May and June. It passed inferior conjunction and became a morning star on April 23d. It continues to be a morning star until June 24th, when it passes superior conjunction and becomes an evening star. It attains its maximum western distance from the Sun (25° 26′) on the morning of May 21st, at a time when it is near aphelion in its orbit; so

the distance is considerably greater than the average greatest elongation. However, it is then so far south of the Sun that its altitude above the horizon at sunrise and its consequent duration of visibility are small. It will at no time during the present period rise as much as an hour before sunrise, and hence can not be easily seen.

Venus passed inferior conjunction on April 27th and became a morning star, and by the end of June will have nearly reached its greatest west elongation. Until May 14th it moves westward among the stars, thus increasing its apparent distance from the Sun quite rapidly. It then begins to move eastward, but lags behind the Sun in their common motion, and follows a path pursued by the Sun some weeks or months before. It is therefore always south of the Sun during this period, and does not rise as long before sunrise as it does when it reaches a similar westward distance from the Sun at another time of the year. On May 1st it rises less than forty minutes before sunrise, and at the end of June about two and one half hours before. It is however very bright, and attains maximum brilliancy on June 2d. For several weeks about this time it will be visible to the naked eye in full daylight.

Mars comes to opposition with the Sun on May 8th. It is then above the horizon throughout the night, and it will not set until long after midnight during the two-month period. At the end of June it sets at about 1 A.M. It is in the constellation *Libra,* and during the two months moves westward (retrogrades) about 12° until June 17th; then it resumes its eastward motion, reaching a position at the end of the month nearly the same as that occupied at the beginning, but a little farther south. When it begins to move eastward (on June 17th) it is about 3° south of the position it held on January 28th, and on August 14th it will reach the position it held on April 2d, the date when it began its retrograde movement, but about 7° south. The whole motion from January 28th to August 14th is in the shape of a gigantic S about 18° in breadth and 10° in height.

At the time of opposition the planet's distance from the Earth is about fifty millions of miles. This is the least opposition distance since the opposition of October 20, 1894, when

the distance was forty millions. The next opposition will occur about July 1, 1907, and the distance will then be considerably less than it is at the present one, and the distance at the next following one will be still less. The opposition distance of Earth and *Mars* is least for an opposition coming near the end of August, because the Earth is at that time between the Sun and the perihelion of *Mars'* orbit. The average time from opposition to opposition is seven hundred and eighty days, but it may be twenty days or more greater or less than this, according to the time of year when opposition takes place, successive oppositions coming during late summer or early autumn being more than eight hundred days apart, while those in late winter or early spring are about seven hundred and sixty days apart.

Jupiter passes conjunction with the Sun on the night of May 3-4th and becomes a morning star. On June 1st it rises about an hour before sunrise, and will be an easy object on account of its brilliancy. On the morning of June 2d it is in conjunction with *Mercury,* the latter planet then being about 2° south of the former, and not easy to see on account of its faintness and low altitude before sunrise. By the end of June *Jupiter* rises about 2 A.M.

Saturn rises at about 2:30 A.M. on May 1st, and at about 10:30 on June 30th. It is in *Aquarius,* and moves slowly eastward until June 14th, and then begins to move westward.

Uranus rises a little after 11 P.M. on May 1st, and comes to opposition with the Sun, rising at sunset, on June 24th. It is still in *Sagittarius,* and moves westward about 2½° during the two months.

Neptune is in the western sky in the evening. It is in the constellation *Gemini,* and comes to conjunction with the Sun on June 30th.

(FORTY-EIGHTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to MICHEL GIACOBINI, astronomer, Nice, France, for his discovery of an unexpected comet on December 17, 1904.

Committee on the Comet-Medal:

W. W. CAMPBELL,
WM. H. CROCKER,
CHAS. BURCKHALTER.

(FORTY-NINTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to A. BORRELLY, astronomer, Marseilles, France, for his discovery of an unexpected comet on December 28, 1904.

Committee on the Comet-Medal:

W. W. CAMPBELL,
WM. H. CROCKER,
CHAS. BURCKHALTER.

NOTES FROM PACIFIC COAST OBSERVATORIES.

The change in the heading of this department of the *Publications* has been under consideration for some time. The substitution of the broader title "Notes from Pacific Coast Observatories" for the "Notices from the Lick Observatory" does not mean that there has been the least change in the intimate and cordial relations that have existed between the Lick Observatory and the Astronomical Society of the Pacific from the time of the Society's inception. It is rather a recognition of the steadily increasing importance of the Pacific Coast as an astronomical center, of which the recent founding of the great Solar Observatory of the Carnegie Institution at Mt. Wilson is substantial evidence; and it is in harmony with the policy of the Directors to make the Society what its name—the Astronomical Society of the Pacific—indicates, representative of the astronomical interests of the entire Pacific Coast.

Notes relating to the observatories west of the Rocky Mountains or to the work of astronomers in this section of the country will be printed in this department. These notes will be signed, and the author will in every case be responsible for the statements made. Notes relating to astronomical work elsewhere, items of interest taken from other periodicals, reviews of astronomical publications, etc., will be printed under the heading "General Notes." These notes may or may not be signed, the Editors accepting full responsibility for those unsigned. Longer articles will, as heretofore, precede these departments.

The co-operation of all members of the Society—and especially of those connected with observatories on the Pacific Coast—in sustaining and increasing the value and interest of the *Publications* is cordially invited.

THE COMMITTEE ON PUBLICATION.

An Electric Lighting, Power, and Pumping Plant for the Lick Observatory.

The Observatory has always been behind the times in the matter of an adequate supply of electric current. The plans for the institution were made in the late seventies and carried out in the early eighties, before it was known what electricity would do, or that it would become a necessity, and an electric plant was not included in the installation. Partly to remedy this defect, the Edison Electric Company presented a three-horse-power plant to the Observatory in 1892. It included a steam-engine and boiler, a one-kilowatt generator, and a small storage battery. This has been indispensable in the scientific work, and for many years has been drawn upon every clear night, on many occasions at a dozen different points in the observing-rooms. However, the capacity of the plant has long since been outgrown, even for exclusively scientific purposes. The work frequently suffers, both in quantity and quality, from the shortage in the supply of current. Facts bearing upon this and other points are brought out in the following paragraphs.

The Crossley dome, set up on Mt. Hamilton in 1895, moves unduly hard, and its operation is a serious tax upon the physical strength of the observers. This dome should be operated by means of an electric motor. The winding of the clock which propels the Crossley reflector has also been a wasteful tax upon the observers' strength, and this work should be done by electric power. Current is needed to illuminate the circles and the guiding mechanism of the telescope and for various other minor purposes in the dome.

The 75-foot steel dome covering the 36-inch refractor is operated by a triple hydraulic engine. This system is only fairly satisfactory, in that the speed of the dome is too slow, the engine requires very frequent attention to keep it in adjustment, and every few years demands a general overhauling. Electric motive power would save valuable time and be more economical in maintenance. The automatic winding device for the driving-clock of this telescope is operated by the same hydraulic system. This device has been in use for two years, and has been very valuable. Nevertheless, it has required frequent attention and repair, due to the fact that the automatic opening and closing of the water-valve is a violent operation.

A satisfactory system can not be installed until electricity is available for power.

The quantity of current which can be drawn upon to maintain the spectroscopes at a constant temperature is entirely too small, and the efficiency of the work suffers in consequence. When the temperature in the great dome falls rapidly, the spectroscopic work must stop for the time, and the enforced idleness of the telescope is uneconomical.

The photometric observations of stars demand a current of constant intensity. This is not practicable with the present small supply.

Current is needed in various other parts of the main building, in the Crocker dome, and elsewhere, for scientific purposes; but it is not at present available.

The Observatory buildings, including all the residences, are illuminated by kerosene lamps. This system is unsatisfactory for many reasons. The work demanded of the janitor and others to fill the lamps and keep them in order is a serious tax. More important still is the element of danger from fire. Our fire risks are unusually great, on account of the general use of lamps and matches, of the proximity of the buildings to each other, and of the prevalence of high winds. The subject is on my mind literally from week to week, and every precaution to guard against the danger is taken: but the greatest source of danger should be removed by the substitution of electric illumination.

Small power plants have been installed here and there to perform our heavy work as required, and they are of various kinds. For example, the water used for domestic and photographic purposes is pumped from the spring into the distributing reservoirs by means of steam generated with wood fuel. For many reasons this work should be done by electric power generated at a central station. Another complete system of waterworks, which supplies power for moving the great dome and its floor, is operated by wind power. This system is satisfactory as to the moving floor, except in the months when there is little wind. During these months the supply in the distributing reservoirs is low, and nearly every fall is entirely exhausted. The result is that work with the great telescope sometimes practically ceases for a week or more in the best sea-

son of the year, and—what is far more serious—when the reservoirs are empty, the Observatory is without adequate fire protection. A pump operated by electric current from a central plant should be installed at once, and be ready to lift water to the distributing reservoirs when the wind fails.

Fuel for the Observatory is purchased in the form of four-foot wood from the neighboring ranchers, who cannot be prevailed upon to supply it in shorter lengths. The Observatory workmen cut the wood into the desired lengths by means of a buzz-saw operated by a separate steam plant.

The machine tools in the instrument-making and carpenter shops are operated by a gasoline engine. Small pieces of work are occasionally performed by means of the current leading directly from the present little generator. At least a dozen small primary batteries are maintained at various points to supply special needs.

The drinking-water system, obtaining its supply from the spring, is of sufficient capacity in ordinary years, provided great care is exercised to avoid all leaks in the pipes; but in years of small rainfall the supply is inadequate. On three occasions in recent years the shortage of rainfall made it necessary for us to reduce to the lowest limits the quantity which could be used for domestic and photographic purposes.

A perfectly practicable method exists for increasing the present supply several fold. One of the largest springs in this vicinity is located on the south slope of the peak which carries the storage reservoirs for drinking-water, at a level 680 feet lower than that of the reservoir, and at a distance of only 1,400 feet down the slope. A responsible pump manufacturer guarantees that an automatic pump, located at a point two hundred feet in level below the spring, will be able to lift one seventh of the total flow up to the reservoirs, the remaining six sevenths being required to operate the pump. Last year the flow in June was approximately fifty thousand gallons per day, and in July thirty-six thousand a day. The daily flow at the end of the last dry season, which was of unusual length, placed it at eighteen thousand gallons. If one seventh of these amounts can be placed in the distributing reservoirs, the necessary demand of the Observatory will be fully met, as the average daily consumption heretofore has been less than two thousand gallons.

With the spring upon which we depend at present held in reserve, there would be little doubt that a considerable surplus of available water would exist, even in years of low rainfall. Should this prove to be the case, plans would be instituted to cover the bare slopes immediately surrounding the Observatory with forest trees. An attempt to develop shade-trees in the early years of the Observatory failed because they could not be irrigated during the dry season. This question is of considerable importance from the scientific point of view. There is little doubt that our atmospheric conditions for observational work, already excellent, would be still better if shade-trees covered the ground. They would prevent the excessive heating in the daytime of the rock and soil surrounding the Observatory, and the consequent rapid radiation of heat in the evening.

It requires no argument to establish that our heterogeneous systems for supplying power and illumination should be replaced by a simple and central electric plant, operated by a gasoline engine. The officers of the General Electric Company have most generously examined into all the above-mentioned requirements and have drawn up plans to meet them, making no charge for the expert services of their engineers. The subject was brought to the attention of the University of California authorities, who petitioned the Governor and the Legislature of the State to make a special appropriation of ten thousand dollars for the expense of installation. This appropriation was generously made at the recent session and the construction will begin at once.

W. W. CAMPBELL.

March, 1905.

NOTE ON THE ORBIT OF COMET *e* 1904.

In an address on "The General Applicability of the Short Method of Determining Orbits from Three Observations," delivered before the Astrometry Section of the International Congress of Arts and Science at St. Louis in September of last year, a criterion was given which makes it possible to decide in the case of a newly discovered planet or comet the limits within which the elements may lie. Comet *e* 1904 (BORRELLY) having been found to be periodic by AITKEN and others from longer arcs, the criterion has been applied to the

short arc of one-day intervals of the first three observations secured by Dr. AITKEN at Mt. Hamilton, in order to decide whether the period could be approximately determined from these first three observations, and it was found that the period in this case is indeterminate. A parabola will satisfy the first three observations, and a number of practical solutions exist. The indeterminateness is due to the nature of the problem, and not to the method used. A. O. LEUSCHNER.

BERKELEY ASTRONOMICAL DEPARTMENT.

LICK OBSERVATORY LECTURES BEFORE THE CLASS IN MODERN ASTRONOMY, UNIVERSITY OF CALIFORNIA.

Director CAMPBELL has announced the following dates and subjects for the annual Lick Observatory lectures to be delivered this spring before the class in Modern Astronomy:—

By Director W. W. CAMPBELL:

1. Tuesday, March 21, 11 A.M.—"Current Eclipse Problems."
2. Saturday, March 25, 9 A.M.—"Current Eclipse Problems," continued.

By Astronomer W. J. HUSSEY:

3. Tuesday, March 28, 11 A.M.—"Present State of Double-Star Astronomy."
4. Thursday, March 30, 11 A.M.—"Concerning Nebulæ and Clusters."

By Assistant Astronomer C. D. PERRINE:

5. Tuesday, April 11, 11 A.M.—"The New Satellites of *Jupiter*."
6. Thursday, April 13, 11 A.M.—"The Solar Parallax from *Eros* Observations."

Dr. TOWNLEY, of the International Latitude Observatory at Ukiah, will follow with two lectures on "Variable Stars." The lectures will be delivered in the lecture-room of the Students' Observatory, and will be open to the public.

A. O. LEUSCHNER.

BERKELEY ASTRONOMICAL DEPARTMENT.

The Sixth Satellite of *Jupiter*.

Owing to its brightness, the sixth satellite has been photographed readily in ten minutes with the Crossley reflector. Plates have been obtained on thirty-six nights, the last observation being on March 22d. The planet is now too near the Sun for the satellite to be observed.

A preliminary investigation of the orbit shows the inclination to the ecliptic and the planet's equator to be about 30°. It has a period of about two hundred and fifty days, its mean distance being about seven million miles.

It is not possible to say yet with certainty what the direction of its orbital motion is.

The large inclination of the orbits of both the sixth and seventh satellites to the plane of the planet's equator suggests that these bodies have not always belonged to *Jupiter,* but that they may be captures.

The actual diameter of these satellites can not be measured, but the brightness indicates a diameter for the sixth of one hundred miles or less.

C. D. Perrine.

1905, March 30.

The Seventh Satellite of *Jupiter*.

An examination of negatives of the sixth satellite taken with the Crossley reflector on January 2d, 3d, and 4th, showed a much fainter object which apparently belong to *Jupiter.* It was then north and west of *Jupiter,* and its motion was toward the planet. The difficulties which presented themselves in determining the true character of the sixth satellite were greater in the case of the new one. Being so much fainter, observations were much more difficult to secure, owing to the long exposures required. Its motion was likewise harder to interpret. However, observations on February 21st and 22d made it clear that it belonged to *Jupiter.*

The seventh satellite is not shown on the negatives of December, it being just outside those fields.

Observations have been secured on twenty nights, the last being on March 9th.

A preliminary investigation of its orbit shows it to be quite eccentric, the mean distance from *Jupiter* being about six mil-

lion miles, with a period of about two hundred days. Its orbit is inclined to the plane of *Jupiter's* equator, at an angle of about 30°. The direction of motion is as yet uncertain.

Its photographic magnitude is estimated to be not brighter than the sixteenth. In comparison with the other satellites and the asteroids this indicates a diameter of about thirty-five miles.

C. D. PERRINE.

1905, March 30.

COMET *a* 1905.

The first comet of the present year has just been discovered by M. GIACOBINI at Nice. According to the telegram received here on Monday, March 27th, the date and position of discovery are as follows: March 26.3212, G. M. T., R. A. $5^h\ 44^m\ 14^s.0$; Decl. $+10°\ 56'\ 56''$.

An observation secured here with the 12-inch telescope on Monday evening gave the position, March 27.6692, G. M. T., R. A. $5^h\ 48^m\ 54^s.85$; Decl. $+12°\ 35'\ 42''.9$.

The comet is small and faint, even when viewed through the 12-inch telescope.

R. G. AITKEN.

March 28, 1905.

NOTE ON THE WORK OF THE D. O. MILLS EXPEDITION TO CHILE.

A recent letter from Professor WRIGHT, in charge of the D. O. Mills Expedition to Chile, informs me that the work of measuring the radial motions of the stars proceeds substantially in accordance with the original programme. The southern winter was an unusually wet and stormy one, but the late spring and early summer (to date) were unusually favorable. As by-products of the investigation Professor WRIGHT reports that he and Dr. PALMER have discovered seventeen spectroscopic binary stellar systems. A recent press dispatch from Santiago, published in the papers of this country, refers to the discovery of twenty new stars. This is a palpable error, and the number undoubtedly refers to the spectroscopic binary systems discovered up to a date considerably later than that of the letter spoken of above.

W. W. CAMPBELL.

ST. LOUIS EXPOSITION AWARDS FOR THE LICK OBSERVATORY EXHIBIT.

In accordance with the decision of the University of California authorities to make an exhibit at the St. Louis Universal Exposition of 1904, the Lick Observatory prepared an extensive collection of transparency views of the buildings and surroundings, of the instruments, and especially of the principal celestial objects and their spectra, together with a complete set of our publications, to form a section of the University exhibit. Unofficial information reached me in November that the departmental juries awarded two grand prizes to the Lick Observatory,—one for the exhibit as a whole, and one for the photographic exhibit. Official confirmation of the awards was received late in March.

W. W. CAMPBELL.

The establishing of the Solar Observatory of the Carnegie Institution on Mt. Wilson, California, is an event which gives great pleasure to the members of the Lick Observatory staff. Although the Lick Observatory and the Solar Observatory are separated by four hundred and fifty miles of railroad, twenty-seven miles of stage-road on Mt. Hamilton, and eight miles of trail on Mt. Wilson, yet the two institutions are neighbors in comparison with the distance that separates us from the Central and Atlantic States. We wish complete success to our neighbor's plans. And may the interchange of neighborly courtesies be numerous and helpful to both institutions.

W. W. CAMPBELL.

The members of the Lick Observatory staff have learned with deep regret that Mr. EDWARD CROSSLEY, the donor of the Crossley reflector, died at Halifax, England, on January 21st. His name is a household word on Mt. Hamilton. Scarcely a day passes that it is not spoken in connection with the work of the Crossley reflecting telescope. The direct results secured with this telescope on Mt. Hamilton indicate only in part the high value of Mr. CROSSLEY'S gift; it is not too much to say that Professor KEELER'S work established for the first time the splendid efficiency of reflecting telescopes in many branches of astronomical photography, whereupon the possession of powerful reflectors became the ambition of astrophysical observers.

W. W. CAMPBELL.

Measurement of Photographic Plates at the Students' Observatory.

Something less than a year ago an instrument for the accurate measurement of photographic plates was received from the makers, Repsold Sons, of Hamburg, Germany. It is of a type which is generally conceded to give the highest accuracy possible in work of this character at something of a sacrifice in the way of speed of manipulation. Much time has been spent investigating the various adjustments of the instrument, the straightness of the bars, scale errors, errors of micrometer-screws, etc., which investigations are a necessary preliminary to the attainment of results of a degree of accuracy which the instrument is capable of giving. In the mean time, over seventy-five plates have been made with two portrait-lenses temporarily attached to the new mounting described by Dr. Gillihan in *Publications of the Astronomical Society of the Pacific* (Vol. XVI, p. 89). Most of these were made with a view to determining the position of some of the Watson asteroids, the orbits of which are now under investigation at this observatory. Measurements have already been made on some of these plates, and others will be measured in time to utilize the results in the final correction of the elements of the asteroids.

Burt L. Newkirk.

Berkeley Astronomical Department.

Tables for the Reduction of Photographic Plates Made with Lenses of Wide Angle.

In connection with the work of the measurement and reduction of the photographic plates made with two portrait-lenses at the Students' Observatory, it has seemed advisable to construct certain numerical tables to simplify the reduction. Three tables, with the help of which the transformation from standard rectangular coordinates to $\alpha - \alpha_0$ and $\delta - \delta_0$ and the converse transformation are to be effected, are at present in course of construction. The tables are to be of such an extent as to be applicable to all stars on a plate covering 10° of Declination and 20° of Right Ascension, and will give results accurate to about 0".01 for stars within 1° of the center, and to about 0".1 for stars farther from the center. These tables can of course be used in reducing measures made on a plate taken with any photographic telescope.

Another series of tables is to be constructed to facilitate the introduction of corrections for refraction and other corrections which are troublesome in reducing measures made on plates covering large areas of the sky.

The formulæ taken as the basis of these tables are those given by Professor TURNER, but the refraction-table will give all of the differential refraction so that the four-constant solution for the plate constants which is recommended by Professor JACOBY may be employed if desired.

BURT L. NEWKIRK.

BERKELEY ASTRONOMICAL DEPARTMENT.

NOTE ON A CORRECTION TO THE SECOND EDITION OF SCHÖNFELD AND KREUGER'S "ATLAS DES NÖRDLICHEN GESTIRNTEN HIMMELS."

Upon comparing two photographic plates taken at the Students' Observatory the night of 1905, March 7, with this map, a star of about 8.5 magnitude contained upon the map in $\alpha = 11^h\ 14^m.1$ and $\delta = +11°\ 25'$ was found missing on the plates. Reference was then made to the Durchmusterung positions, and no star was found having these coordinates, showing the Atlas position to be an error.

RUSSELL TRACY CRAWFORD.

BERKELEY ASTRONOMICAL DEPARTMENT.

THE VARIABLE RADIAL VELOCITY OF *SIRIUS*, AND THE INCLINATION OF ITS ORBIT-PLANE.

The determination of a double-star orbit from micrometer observations of the primary star and its companion leaves an ambiguity as to the inclination of the orbit-plane to the line of sight. There are two positions of the orbit-plane which satisfy the observations equally well. At any given instant the companion may lie beyond the primary or at an equal distance this side of the primary. The orbital motion of the companion may be carrying it either further from the observer or nearer to him. The observations do not permit us to decide which of the two positions is the correct one.

If the two stars are also observable accurately by means of a spectrograph for motion in the line of sight, a comparison of their speeds toward or from the observer will remove the ambi-

guity in the value of the inclination of the orbit-plane. If only one of the stars is observable spectrographically, the removal of the ambiguity requires that the observations be continued long enough to decide as to whether it is the orbital motion to or from the observer that is accelerating.

The parallax and the elements [1] of the orbits of the binary star *Sirius* are probably more accurately determined than in the case of any other double star, with the possible exception of *α Centauri*. ZWIERS's elements on the above system are: [2]

$$
\begin{aligned}
P &= 48.8421 \text{ years} \\
T &= 1894.0900 \\
a &= 7''.594 \\
e &= 0.5875 \\
\Omega &= \quad 44^\circ\ 30'.2 \ (1900.0) \\
\omega &= \quad 147\ \ 53.6, \text{ position angles decreasing} \\
i &= \pm\, 46\ \ 01.9 \\
\mu &= 7^\circ.37069
\end{aligned}
$$

The weighted mean value of the Cape of Good Hope determinations of the parallax is 0''.37. [3] AUWERS's result [4] for the relative masses of *Sirius* and its companion is 2.20 : 1.04.

LEHMANN-FILHÉS [5] has developed a very convenient formula for determining the radial velocity of a star due to its orbital motion.

If we let the radial velocity V be expressed in kilometers per second, a in seconds of arc, P in mean solar years, π'' the star's parallax in seconds of arc, 149,500,000 the mean distance of the Sun in kilometers corresponding to a solar parallax of 8''.80, and let v represent the true anomaly at the instant for which V is desired, then

$$V = \frac{149{,}500{,}000\, a\, 2\, \pi \sin i}{365.25 \quad 86{,}400\, \pi''\, P \sqrt{1 - e^2}} \left[e \cos \omega + \cos (v + \omega)\right],$$

or
$$V = [1.^{6}47372]\ \frac{a \sin i}{\pi''\, P \sqrt{1 - e^2}} \left[e \cos \omega + \cos (v + \omega)\right].$$

Care must be taken to distinguish between the motions of the companion with reference to the primary, and of the pri-

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[1] For definitions of the elements used in defining the orbit of a double star, see articles by CAMPBELL and AITKEN in *Lick Observatory Bulletin*, Nos. 70 and 71, respectively.

[2] Proceedings of the Amsterdam Academy of Sciences, May 27, 1899.

[3] Sir DAVID GILL, *Mon. Not. R. A. S.*, Vol. 58, 81, 1898.

[4] *Astronomische Nachrichten*, Vol. 129, 232, 1892.

[5] *Astr. Nach.*, Vol 136, 19, 1894, equation (2).

[6] Logarithm of the factor constant for all orbits.

mary and secondary with reference to the center of mass ot the system.

The value of V for the companion of *Sirius* with reference to the primary becomes

$$V = \mp 5.536 \pm 11.125 \cos (v + 147^\circ 53'.6).$$

It follows, from AUWERS's values of the relative masses, that the radial velocities of the primary, with reference to the center of mass of the system, are given by

$$V_1 = \pm \frac{1.04}{3.24} [-5.536 + 11.125 \cos (v + 147^\circ 53'.6)]$$

$$V_1 = \mp 1.777 \pm 3.571 \cos (v + 147^\circ 53'.6).$$

The maximum relative velocities of approach and recession occur at the two nodal points of the orbit,—that is, when the primary and companion are at the same distance from the observer,—and the extreme range of the primary's speed is the arithmetical sum of these maxima, or $5.35 + 1.79 = 7.14^{km}$.

The bright component of *Sirius* is easily observable for motion in the line of sight. Thirty-three spectrograms have been secured with the Mills spectrograph since the year 1896. Mr. KEIVEN BURNS, Carnegie Assistant in the Lick Observatory, has recently made definitive measures of all of them. The following table contains these observations, as well as those made at the Potsdam, Paris, and Yerkes observatories, which are all that are known to me. They are combined into groups, those forming each group covering only a short interval of time. The number of observations in each group is indicated in column three. The negative sign in column four indicates approach.

Neglecting the plate of 1898.07, which is very poor and stands alone, there is an unmistakable progression in the results, which we attribute to the effect of orbital motion. Whether the irregularities in the progression are real, and due to unrecognized disturbing forces in the system, or are purely accidental, cannot now be stated; but they should be examined in connection with future series of observations.

The observed progression is in the direction of algebraically decreasing velocities, and this determines that the positive value

of the inclination i, $+44° 30'.2$, is the correct one, and that the negative sign of i is to be discarded.

The observed velocity should equal the computed orbital velocity plus the velocity of the center of mass of the system. If we let V_m represent the velocity of the center of mass, then each observation supplies an equation of the form

$$V_m = V_{\text{observed}} - V_1.$$

Combining the thirty-three equations, we obtain as the velocity of the system of *Sirius*,

$$V_m = -7.4^{\text{km}} \text{ per second.}$$

The computed relative orbital velocity, V_1, of the primary is given in column five. The last column contains the corresponding values of $V_1 + V_m = V_1 - 7.4^{\text{km}}$.

Observations made at	Date.	No. of Observations Combined.	Observed Velocity.	V_1	$V_1 + V_m$
Potsdam	1888.99	3	-13.9^{km}	-0.92^{km}	-8.3^{km}
Potsdam	1890.09	3	-17.0	-0.37	-7.7
Paris	1891.17	1	-1.2	$+0.49$	-6.9
Potsdam	1891.20	4	-14.9	$+0.52$	-6.8
Paris	1895.21	1	-4.1	$+5.30$	-2.1
Lick	1896.97	8	-3.2	$+4.26$	-3.1
Lick	1898.07	1	$[-5.9]$	$+3.43$	-3.9
Lick	1898.74	4	-3.6	$+2.99$	-4.4
Lick	1899.92	6	-4.8	$+2.33$	-5.0
Lick	1901.93	1	-4.8	$+1.47$	-5.9
Yerkes	1902.06	10	-6.9	$+1.42$	-5.9
Lick	1903.07	9	-6.9	$+1.09$	-6.3
Lick	1904.95	2	-5.4	$+0.58$	-6.8
Lick	1905.12	2	-7.4	$+0.54$	-6.9

Assuming that GILL's parallax, ZWIERS's elements, and AUWERS's relative masses of the two stars are correct, the fourth and sixth columns should agree. We are justified, I think, in attributing the differences between the values in the columns almost entirely to errors in the observations.

W. W. CAMPBELL.

Note on the Binary Stars β 208 and β 524.

Two recent observations of the binary star β 208 made with the 36-inch telescope show that the angular motion of the companion-star has been fully 90° since 1898. The distance has diminished decidedly in the same interval. My measures give the following position:—

1905.18	167°.6	0″.30	2^n.

If, as now seems likely, the orbit is very eccentric, it will be possible in five or six years to compute a satisfactory orbit for this pair. The system is also of interest because of its large proper motion—0″.48 in the direction 328°.

The binary star 20 *Persei* = β 524 has for several years been a difficult object to measure, even with the 36-inch telescope. The apparent distance between the components is now increasing, and will probably continue to increase for a number of years, though its maximum value will not greatly exceed 0″.3. As this pair belongs to the class of short-period binaries, the periodic time not being much more than thirty years, it deserves annual measures by observers having telescopes adequate to such work.

My last measures are:—

1904.83	5°.8	0″.16	2^n.

March 24, 1905. R. G. Aitken.

Note on Comet *c* 1904.

Comet *c* 1904, discovered by M. Borrelly on December 28, 1904, has proved to be an object worthy of more attention than was at first suspected, for it is traveling in an elliptic orbit, and hence is a member of the solar system, not a chance visitor.

This discovery was made by M. Fayet at Paris, and, independently, by the present writer. My orbit, based upon my observations of December 31, 1904, January 17, and January 27, 1905, gives a period of 7.3 years; M. Fayet's revised elements, derived from normal places representing the observations from December 30, 1904, to January 26, 1905, make the period a little shorter, 7.0 years.

In other respects the two orbits are very similar, and the

ephemerides to April 1st, computed from them, differ but little, either set being amply accurate for the observer's purpose.

An observation secured with the 36-inch on March 22, 1905, indicates a motion a very little more rapid than that predicted, and it is probable that a definitive discussion of the observations made at this apparition will give a period falling a little under seven years.

The comet is now too faint for good observations with a 12-inch telescope, and is not likely to be visible very much longer, even with the 36-inch.

R. G. AITKEN.

March 24, 1905.

INTERNATIONAL LATITUDE OBSERVATORY, UKIAH, CAL.

The programme of the International Geodetic Association for observing variations of latitude was continued throughout 1904 without modification or interruption. Good observing weather prevailed throughout the year, except during the months of February and March, when thirty-one inches of rain fell. Meteorological observations have been kept at Ukiah for twenty-seven years, and 1904 is the first year during that time in which a measurable amount of rain fell every month. The three longest intervals without observations were seven nights in April, fourteen nights in August and nine nights in October. The interval in August was caused by the absence of the observer from the observatory; those in April and October to a combination of unfavorable weather and the absence of the observer.

The following table gives a summary of the observations made for the variation of latitude. The second column gives the number of nights in each month on which observations were obtained. The last column gives the greatest interval each month during which no observations were obtained:—

1904.	Pairs.	Nights.	Nights.
January	242	16	4
February	114	10	4
March	122	10	5
April	182	13	7
May	239	15	6
June	197	15	5

1894.	Pairs.	Nights.	Nights.
July	271	18	6
August	219	15	14
September	232	16	4
October	249	17	9
November	196	16	6
December	171	12	6
Totals	2434	173	

The probable error of a single determination of latitude, computed from 183 observations of zenith pairs, made during November and December, was found to be $\pm 0''.109$.

The meridian targets, by which the azimuth of the instrument is controlled, have remained in excellent adjustment ever since they were put in place in the fall of 1899. The error of adjustment since that time has been always less than one second of time.

SIDNEY D. TOWNLEY.

GENERAL NOTES.

Personal Scale.—After making about three thousand photometric settings, it occurred to the writer to determine his "personal scale" in the estimation of tenths of a division, as formerly done by Dr. FRANK SCHLESINGER and published in this journal. (Vol. XV, p. 207.) During the past year I have also made time observations and clock-comparisons which give data for similar determinations.

The photometer readings were made on a circle divided into single degrees. The observer's attention was fixed on making sure of the whole number of degrees, and no great pains were taken to determine the tenth. The series of readings was divided into six sets of 500. Below is given a table of percentages of times that each tenth was estimated. The original per cents and means were taken one place farther, but it seems best to round off the results:—

Tenths.	First 500.	Second 500.	Third 500.	Fourth 500.	Fifth 500.	Sixth 500.	Mean.
.0	28	28	26	25	21	25	25
.1	4	6	3	5	7	6	5
.2	10	8	11	8	7	5	8
.3	8	6	8	7	11	9	8
.4	11	10	11	17	11	9	12
.5	13	11	9	14	13	13	12
.6	10	10	8	8	10	12	10
.7	4	4	7	5	7	7	6
.8	7	13	12	9	9	10	10
.9	5	4	5	2	4	4	4
	—	—	—	—	—	—	—
	100	100	100	100	100	100	100

All of the above estimates were made before the observer had thought whether he was giving preference to any tenth or not. I might have foretold that there would be an excess of zeros, but it was a surprise to find so many. I seem to have a habit of rounding off a one or a nine to a zero. A preponderance of twos and eights over the adjacent odd digits,

would also be expected, as my habit in computing is to choose the even number in dropping a final five.

The estimates in photometer-readings were made when the observer had plenty of time, but was paying little attention to the exact tenth. We might therefore expect an entirely different "personal scale" in observing eye-and-ear transits. I have counted the tenths in a number of time-observations, made with a three-inch transit throughout a period which included that of the photometric work. In the time series the principal aim was to determine the tenth of a second by estimates of spaces on each side of a wire. The chronometer beats half seconds, but the space was estimated at each second. The observations have been grouped according to declination, the first group containing some stars south of the equator.

Declination. Tenths.	S. of 40°. 352 Transits.	40°-60°. 163 Transits.	60°-80°. 263 Transits.
.0	25	27	32
.1	10	4	5
.2	8	5	11
.3	4	6	3
.4	9	8	4
.5	18	28	28
.6	5	5	4
.7	3	5	3
.8	11	7	11
.9	7	5	3
	100	100	100

There are more zeros and fives, especially in the case of the slow north stars, where many estimates could only be made to the nearest half-second.

It is my daily habit to compare a mean time with a sidereal clock. Each clock beats seconds and the difference is estimated to tenths. There was always plenty of time for the estimate, but I did not wait for the coincidence of beats. The results of the two other series are printed again for comparison with the clock set.

Tenths.	Photometer. 3,000 Readings.	Time Stars. S. of 40°. 352 Transits.	Clocks. 246 Comparisons.
.0	25	25	30
.1	5	10	3
.2	8	8	11
.3	8	4	10
.4	12	9	5
.5	12	18	9
.6	10	5	9
.7	6	3	9
.8	10	11	12
.9	4	7	6
	100	100	100

The photometer readings were made wholly with the eye, the transits with eye and ear, and the clock-comparisons with ear alone. The conditions being so different, we would expect the "scales" to be very unlike. I see no reason for endeavoring to make the scale uniform, but for a time I shall probably remember and not record so many zeros, and perhaps be careful to see more sevens. JOEL STEBBINS.

UNIVERSITY OF ILLINOIS OBSERVATORY, February, 1905.

At the meeting of the American Association for the Advancement of Science, held in Philadelphia during Convocation Week, Professor ALEXANDER ZIWET, of the University of Michigan, presided over Section A, Mathematics and Astronomy. Professor W. S. EICHELBERGER, of the Naval Observatory, was elected vice-president of the section for the next meeting. Following is a list of the astronomical papers presented at the meeting:—

Synchronous Variations in Solar and Meteorological Phenomena: H. W. CLOUGH, U. S. Weather Bureau, Washington, D. C.

Temperature Corrections of the Zenith Telescope Micrometer, Flower Astronomical Observatory: C. L. DOOLITTLE, University of Pennsylvania.

Results from Observations of the Sun, Moon, and Planets for Twenty-six Years: J. R. EASTMAN, Andover, N. H.

Determination of the Solar Rotation Period from Flocculi Positions: PHILIP FOX, Yerkes Observatory.

The Computation of the Deflections of the Vertical Due to the Topography Surrounding the Stations: J. F. HAYFORD, U. S. Coast and Geodetic Survey, Washington, D. C.

On Systematic Errors in Determining Variations of Latitude: Some Experiments on the Distortion of Photographic Films: FRANK SCHLESINGER, Yerkes Observatory.

Bibliography and Classification of Mathematical and Astronomical Literature at the Library of Congress: J. D. THOMSON, Library of Congress, Washington, D. C.

On an Optical Method of Radial Adjustment of the Axes of the Trucks of a Large Observatory Dome: DAVID TODD, Director of Amherst College Observatory.

The Application of MAYER'S Formula to the Determination of the Errors of the Equatorial: L. G. WELD, State University of Iowa.

The annual general meeting of the Royal Astronomical Society took place in London on February 10th, when the American Ambassador, the Hon. J. H. CHOATE, attended to receive the Society's gold medal, which has this year been awarded to Professor LEWIS BOSS, director of the Dudley Observatory, Albany, New York, for his long-continued work on "The Positions and Proper Motions of Fundamental Stars." Professor BOSS has distinguished himself as an astronomer not only in America, but in other countries, where he has been elected to the membership of prominent scientific associations, notably the Royal Astronomical Society, the National Academy of Sciences, and the Astronomische Gesellschaft, Leipzig. He is the author of numerous valuable monographs on astronomical topics.

The Jackson-Gwilt medal of the Society, which is awarded occasionally for work of the less ambitious kind, was given this year to Mr. JOHN TEBBUTT, an amateur astronomer, of New South Wales, who has maintained an observatory for forty years.

The assistant secretary, Mr. WESLEY, was presented with a purse of money, as a token of the Society's appreciation of his work during the thirty years he has now held his office.—*London Standard.*

The sixth meeting of the Astronomical and Astrophysical Society of America was held in Philadelphia during Convocation Week, in affiliation with the American Association for

the Advancement of Science. Professor SIMON NEWCOMB was again re-elected president of the Society. The list of papers presented, abstracts of which may be found in *Science* for March 17th, was as follows:—

The Constant of Aberration: C. L. DOOLITTLE.
A Test of the Transit Micrometer: JOHN F. HAYFORD.
Remeasurement of the Hough Double Stars: ERIC DOOLITTLE.
Novel Design for Rotating Dome Track: D. P. TODD.
A Study of Driving-Worms of Photographic Telescopes: E. S. KING.
The Reflex Zenith Tube: C. L. DOOLITTLE.
Variations of the Bright Hydrogen Lines in Stellar Spectra: ANNIE J. CANNON.
Variable Stars in Large Nebulous Regions: HENRIETTA S. LEAVITT.
Planetary Spectrograms, the Work of V. M. SLIPHER and C. O. LAMPLAND: PERCIVAL LOWELL.
The Canals of *Mars*: an Investigation of Their Objectivity: PERCIVAL LOWELL.
Note on Three Solar Periods: FRANK H. BIGELOW.
The Coordination of Visual and Photographic Star Magnitudes: JOHN A. PARKHURST.
The Quadruple System of *Alpha Geminorum*: HEBER D. CURTIS.
Use of the Method of Least Squares to Decide Between Conflicting Hypotheses: HAROLD JACOBY.
Tables for the Reduction of Astronomical Photographs: HAROLD JACOBY.
Recent Researches of the Henry Draper Memorial: EDWARD C. PICKERING.
Calibration of a Photographic Photometer Wedge: ORMOND STONE.
Note on Two Variable-Star Catalogues: J. G. HAGEN.
Useful Work for a Small Equatorial: Discussion, opened by EDWARD C. PICKERING.

The following notes have been taken from recent numbers of *Science*:—

The Observatory of Amherst College is to have a new equatorial telescope of eighteen inches aperture. The glass for the objective, which is now completed, was cast by MANTOIS of Paris, and the lenses were ground by Mr. C. A. R. LUNDIN, optical expert of the firm of Alvan Clark & Sons.

Professor A. AUWERS, the eminent astronomer of Berlin, has been elected an honorary member of the St. Petersburg Academy of Sciences.

M. PAUL HENRY, the French astronomer, died on January 4th, as a result, it is said, of a cold in the Alpine Observatory

on Grand-Montrouge. This was also the cause of the death of his brother PROSPER, who died in 1903. The brothers are well known for the work that they carried on together in astronomical photography, especially in connection with the great international chart of the heavens.

Professor ERNST ABBE, of Jena, well known for his important improvements in the microscope and other optical instruments, which he constructed in partnership with CARL ZEISS, died on January 16th at the age of sixty-four years.

M. JANSSEN, director of the Observatory at Meudon, has been elected a member of the St. Petersburg Academy of Sciences.

M. S. J. P. FOLIE, honorary director of the Observatory of Brussels, died on January 29th, at the age of seventy-one years. The death is also announced of Professor T. BERTELLI, the Italian astronomer.

Dr. E. O. LOVETT, professor of mathematics of Princeton University, has been elected professor of astronomy to succeed Professor C. A. YOUNG, who has become professor emeritus.

Mr. EDWARD CROSSLEY, of Halifax, England, and a member of the Astronomical Society of the Pacific, died on January 21st in his sixty-third year. He had been three times Mayor of the borough, and was a Member of Parliament for seven years. Apart from his engrossing business pursuits, the late gentleman was devotedly attached to the study of astronomy, and was a Fellow of the Royal Astronomical Society. He will be best known on the Pacific Coast as the donor of the Crossley reflecting telescope at the Lick Observatory, with which much useful work in celestial photography has been accomplished; and it was by means of this instrument that the sixth and seventh satellites of *Jupiter* were discovered.

Royal Philosophical Society of Glasgow.—At a meeting of the Royal Philosophical Society of Glasgow—Dr. DAVID MURRAY presiding—Professor L. BECKER, Ph.D., delivered the centenary lecture on "The Progress of Astronomy in the Nineteenth Century." Treating of the constitution of the Sun, the

lecturer explained the spectroscopic and photographic evidences which had led to present-day views regarding that subject. The whole body, he said, was considered to be in a gaseous state, pressure and temperature steadily increasing inwards. At the level of the Sun's visible outline, where the pressure of the gases is about five atmospheres, and the temperature six thousand degrees centigrade, the conditions are such that some of the gases, carried upwards by currents or explosions, condense and form clouds. From this sheet of clouds we receive our light and heat. Most of the elements occur in the solar atmosphere, but in the interior of the Sun they are probably in the state of combination. When by any cause the mixture of gases moves from the interior upwards, where pressure and temperature are less, dissociation will ensue resembling an explosion. Gases will rush to the surface, giving the appearance of a prominence, and cooling by expansion, clouds will be formed at a high level in the solar atmosphere. The eruption is analogous to a cyclone in our atmosphere, and it is accompanied by an anticyclone. The gases will become heated in their downward motion and dissolve the cloud sheet below. At the same time the withdrawal of matter below is followed by an inrush of gases from the surrounding regions. They will cool by expansion, and produce the comparatively dark layer which, viewed from the opening in the cloud sheet, appears as the dark background of a sun-spot. The corona which emerges from the solar atmosphere is supposed to consist of detached exceedingly small particles, which float near the Sun, their weight being balanced by the pressure of the light-rays. Negatively charged particles of a similar size are pushed into space by the light-rays, and they form the connection between solar activity and magnetic disturbances on the earth.—*The Scotsman.*

To be an Astronomer.—The late Dr. E. A. MEREDITH, one of the presidents of the Toronto Astronomical Society, said that Sir WILLIAM ROWAN HAMILTON, Astronomer Royal of Ireland, when asked, at a time when *Saturn* was favorably placed, if he had been observing that planet, replied, "No; he left that for others—the mathematics of astronomy were enough for him." So even Sir ISAAC NEWTON had FLAMSTEED make the

lunar observations on which he depended for the verification of his theory of gravitation. One may be an astronomer without using the telescope. But if one desires to be an observational astronomer, he must, according to Dr. D. B. MARSH, of Hamilton, possess: (1) A sound physical frame; (2) Enthusiasm such that the cold of winter or the heat of summer, or even the feeling of weary bones by night or by day, will not prevent observation and making records thereof; (3) He must use faithfully what equipment he has and remove the word "can't" from his vocabulary; (4) Undertake work that seems to him difficult and stay with it until he has mastered it; then take up another problem and persevere with that likewise.—*From the Proceedings of the Royal Astronomical Society of Canada, 1902 and 1903.*

The Date of Easter in 1905.—The Prayer-Book rule for finding the date of Easter runs thus: "Easter-day is always the first Sunday after the full moon which happens upon, or next after, the twenty-first day of March; and if the full moon happens upon a Sunday, Easter-day is the Sunday after." But according to the almanacs the Moon is full at 4^h 56^m, Greenwich mean time, on the morning of March 21, 1905. Why, then, is not Easter-day in 1905 the following Sunday—viz., March 26th—instead of April 23d, the date given in the almanacs? Is the Prayer-Book wrong, or is the Nautical Almanac wrong?

This is the dilemma that has been put to me by anxious inquirers, and as the misunderstanding seems prevalent, even amongst educated people, I should like to give a few words of explanation.

In the first place, I am happy to be able to give an assurance that in this particular instance neither of the authorities referred to above is wrong.

The explanation of the apparent contradiction is simply that a different "Moon" is referred to in the two cases. The "Moon" of the ecclesiastical calendar is an imaginary body, which is so controlled by specially constructed tables as to be "full" on a day (no attempt is made in the calendar, either in the date of the vernal equinox or in that of the full moons, to subdivide the day) not differing by more than two or three days at most from the date on which the actual Moon is full.

The adoption of the calendar Moon for such a purpose as fixing the date of Easter has certain practical advantages, such as applicability to every terrestrial longitude, that would not be present in the case of the actual Moon. Thus in the instance quoted above, in which the Moon is full at $4^h\ 56^m$ Greenwich time on the morning of March 21st, we see at once that for places adopting a time five hours west of Greenwich (the eastern standard time of the United States) this Moon would be full on March 20th. And so in the circumstances supposed Easter would be celebrated on a different date, depending on the adopted time at different meridians. This inconvenience is avoided by adopting the calendar Moon.

A very convenient expression for the date of the Easter full moon of the calendar is March (44 — epact), which gives the date directly when the epact is less than 24. When the epact is equal to or greater than 24, the date given by the formula is that of the preceding calendar full moon, and the Easter full moon is found by adding 29.

In 1905 the epact is 24. The calendar Moon is, therefore, full on March 20th, and again on April 18th. The latter then is the Easter full moon of the calendar, and Easter-day is the following Sunday, April 23d.—*A. M. W. Downing, in the Journal of the British Astronomical Association, Vol. 15, No. 3.*

Solar Eclipse Expedition.—An expedition from Indiana University, in charge of JOHN A. MILLER, Professor of Mechanics and Astronomy, and W. A. COGSHALL, Assistant Professor of Astronomy, will go to Spain to observe the total solar eclipse that occurs on August 30th. At some point in northeastern Spain, on a favorable site chosen by Professor A. F. KUERSTEINER, of the Department of Romance Languages, who is now in Spain, they will install their instruments. This temporary observatory will include a horizontal photographic telescope about seventy-five feet long, having an aperture of eight inches. Into this telescope the Sun's rays will be reflected by a mirror moving at such a rate that it will reflect rays in a constant direction. This telescope, with one exception, will have greater photographic efficiency than any telescope that has hitherto been used to photograph the Sun during a total eclipse, and is designed to secure photographs of the corona on a very larger scale.—*Science, March 17, 1905.*

Professor GEORGE E. HALE has resigned the directorship of the Yerkes Observatory, and Professor E. B. FROST has been appointed to the position.

Professor F. L. O. WADSWORTH has resigned the position of Director of the Allegheny Observatory and accepted the appointment of General Manager of the Pressed Prism Plate Glass Company of Morgantown, W. Va. Dr. FRANK SCHLESINGER, of Yerkes Observatory, becomes Professor WADSWORTH's successor in the directorship of the Allegheny Observatory.

Minutes of the Meeting of the Board of Directors, held at the University Club, San Francisco, March 25, 1905, at 5 p.m.

President Edwards presided. A quorum was present. The following members were duly elected:—

List of Members Elected March 25, 1905.

Mr. O. V. Lange	1400 Milvia St., Berkeley, Cal.
Mr. C. A. G. Weymouth . . .	2325 Blake St., Berkeley, Cal.

Professor Geo. E. Hale and Mr. E. C. Smith were elected to life membership.

Report of the Library Committee.

San Francisco, Cal., March 25, 1905.

To the Board of Directors of the Astronomical Society of the Pacific:

We, the undersigned Committee of the Society's Library, report as follows:—

Since the last annual report a catalogue of the bound books of the Library has been published, as number 97, volume 16, of the *Publications* of this Society. The number of volumes on the accessions-book is now 1,347.

Before publishing the catalogue it was desirable to bring the binding up to date, and the cost of this, together with the cost of preparing the catalogue, made it necessary to draw on the principal of the Alexander Montgomery Library Fund, so that at the time of the Treasurer's last annual report this fund amounted to $1,415. It has been the policy in the past, and we believe it to be a good one, to keep this fund at not less than $1,500. During the past year, therefore, practically no expenditures have been made from this fund, and none will be made until the fund again reaches $1,500. The fund at present amounts to $1,470.

Respectfully submitted,

S. D. Townley, *Librarian.*
A. H. Babcock.
Rose O'Halloran.

The name of Professor Campbell was added to the committee, consisting of Messrs. Aitken and Townley, to prepare resolutions regarding the proposed amendment of Article II of the By-Laws.

It was upon motion,

Resolved, That the Publication Committee be instructed to print, whenever a list of members of the Society is printed, the names of the Bruce Medalists of the Society, at the head of the list of members.

For the purpose of increasing the usefulness of the Society through the increase of its membership, it is the sense of the Board of Directors that a material reduction in the annual dues be made, beginning with the 1st of January next following the date when the active membership shall have reached three hundred members.

Adjourned.

Minutes of the Seventeenth Annual Meeting of the Astronomical Society of the Pacific, held in the Lecture Hall of the California Academy of Sciences, March 25, 1905, at 8 p.m.

The meeting was called to order by President Edwards. A quorum was present. The minutes of the last meeting were approved.

The following papers were presented:—

1. An Eclipse Problem, by Professor W. W. Campbell.
2. The Sixth and Seventh Satellites of *Jupiter*, by Professor C. D. Perrine.
3. The Development of a New Observatory, by Professor Geo. E. Hale.

President Edwards introduced the lecturers, who read their respective papers. In the absence of Professor Hale, his paper was read by Dr. Townley.

The Committee on Nominations reported a list of names proposed for election as Directors, as follows: Messrs. R. G. Aitken, A. H. Babcock, Chas. Burckhalter, W. W. Campbell, Wm. H. Crocker, Chas. S. Cushing, Geo. E. Hale, A. O. Leuschner, Geo. C. Pardee, S. D. Townley, F. R. Ziel.

For Committee on Publication: Messrs. R. G. Aitken (Chairman), S. D. Townley, B. L. Newkirk.

Messrs. Burckhalter and Irving were appointed as tellers. The polls were open from 8:15 to 9 p.m., and the persons above named were duly elected to serve for the ensuing year.

Report of the Committee on the Comet-Medal, Submitted March 25, 1905.

This relates to the calendar year 1904. The comets of 1904 have been: Comet *a* (unexpected comet), discovered by Dr. W. R. Brooks, Geneva, New York, on April 16, 1904; Comet *b* (Encke's periodic comet), rediscovered by Herr A. Kopff, at Kœnigstuhl-Heidelberg, Germany, on September 11, 1904; Comet *c* (Tempel's periodic comet), rediscovered by M. St. Javelle, at Nice, France, on November 30, 1904; Comet *d* (unexpected comet), discovered by M. Michel Giacobini, at Nice, France, on December 17, 1904; Comet *e* (unexpected comet), discovered by M. A. Borrelly, Marseilles, France, on December 28, 1904.

The Donohoe Comet-Medal of the Society has been awarded to the discoverers of comets *a*, *d*, and *e*, in accordance with the regulations. Forty-nine awards of the medal have been made to date.

Respectfully submitted,

W. W. Campbell,
Wm. H. Crocker,
Chas. Burckhalter,
Committee on the Donohoe Comet-Medal.

The Treasurer submitted his Annual Report as follows: —

ANNUAL STATEMENT OF THE RECEIPTS AND EXPENDITURES OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC FOR THE FISCAL YEAR ENDING MARCH 25, 1905.

GENERAL FUND.

Receipts.

1904, March 27th. Cash Balance			$ 215 49
Received from dues for 1904 and previous years	$342 35		
" " " " 1905	574 50	$916 85	
" " Life membership fees		150 00	
" " sales of Publications		33 50	
" " " " Stationery		50	
" " Life Membership Fund (interest)		67 51	
" " John Dolbeer Fund (interest)		233 42	1,401 78
			$1,617 27
Less transfer to Life Membership Fund			150 00
			$1,467 27

Expenditures.

For Publications: printing Nos. 95 to 100	$695 50		
illustrations	47 07	$742 57	
Stationery and printing	117 30		
Postages	62 08		
Rent	180 00		
Salary Secretary-Treasurer	180 00		
Expressages	12 20		
Telephone and Telegrams	1 70		
Janitor	2 00		
Gas	1 20		
Insurance premiums	21 55		
Lantern at lecture	7 25		
Engrossing	15 75		
Taxes	2 48		
Rent safe deposit box	5 00		
Bank Exchanges	65		
Notary Fee	50	609 66	1,352 23
1905, March 25th. Cash Balance			$ 115 04

Dues outstanding:

for 1904	$ 50 00
for 1905	275 00
	$325 00

LIFE MEMBERSHIP FUND.

1904, March 27th. Cash Balance		$1,753 95
Received from General Fund (fees)		150 00
Interest		67 51
		$1,971 46
Less transfer to General Fund (interest)		67 51
1905, March 25th. Cash Balance		$1,903 95

ALEXANDER MONTGOMERY LIBRARY FUND.

1904, March 27th. Cash Balance		$1,415 61
Interest		64 12
		$1,479 73
Less expenditures:		
Hicks-Judd Co., binding	1 40	
Clerke, *Astrophysics*	5 00	
Popular Astronomy, subscription, Nos. 121 to 130	2 50	8 90
1905, March 25th. Cash Balance		$1,470 83

DONOHOE COMET-MEDAL FUND.

1904, March 27th. Cash Balance	$724 35
Interest	25 91
	$750 26
Less engraving medals Nos. 46 and 47, and postage	2 71
1905, March 25th. Cash Balance	$747 55

BRUCE MEDAL FUND.

1904, March 27th. Cash Balance	$2,526 48
Interest	123 92
1905, March 25th. Cash Balance	$2,650 40

JOHN DOLBEER FUND.

1904, March 27th. Cash Balance	$5,000 00
Interest	233 42
	$5,233 42
Less interest expended for *Publications* (see resolution, No. 95, page 131)	233 42
1905, March 25th. Cash Balance	$5,000 00

FUNDS.

Balances as follows:

General Fund:		
with Donohoe-Kelly Banking Co		$115 04
Life Membership Fund:		
with San Francisco Savings Union	$ 403 95	
" German Savings and Loan Society	300 00	
" Hibernia Savings and Loan Society	200 00	
South Pacific Coast Railway Co., $1,000 Bond, No. 3,406	1,000 00	1,903 95
Alexander Montgomery Library Fund:		
with San Francisco Savings Union	$ 171 51	
" German Savings and Loan Society	184 86	
" Hibernia Savings and Loan Society	74 46	
Oakland Transit Consolidated, $1,000 Bond, No. 4,328	1,040 00	1,470 83
Donohoe Comet-Medal Fund:		
with San Francisco Savings Union	$ 229 87	
" German Savings and Loan Society	253 24	
" Hibernia Savings and Loan Society	264 44	747 55
Bruce Medal Fund:		
with San Francisco Savings Union	$ 224 96	
" Security Savings Bank	216 51	
" German Savings and Loan Society	219 21	
Bay Counties Power Co., $1,000 Bond, No. 1,636	1,012 50	
The Edison Electric Co., $1,000 Bond, No. 168	977 22	2,650 40
John Dolbeer Fund:		
with Union Trust Co.	570 28	
" Mutual Savings Bank	400 00	
South Pacific Coast Railway Co., $1,000 Bond, No. 3,407	1,000 00	
Oakland Transit Consolidated, $1,000 Bond, No. 4,329	1,040 00	
Bay Counties Power Co., $1,000 Bond, No. 1,637	1,012 50	
The Edison Electric Co., $1,000 Bond, No. 169	977 22	5,000 00
		$11,887 77

San Francisco, March 25, 1905.

F. R. Ziel, *Treasurer.*

Examined and found correct.

Chas. S. Cushing,
Armin O. Leuschner,
Daniel Suter,
} *Auditing Committee.*

The report was, on motion, accepted and filed.

The following resolution was, on motion, adopted:—

Resolved, That all the acts appearing in the minutes of the meetings of the Board of Directors of this Society, as having been done by said Board during the past fiscal year, are here, now, by this Society, approved and confirmed.

Upon motion by Professor CAMPBELL, the thanks of the Society were returned to the retiring President, Professor EDWARDS, for the services rendered by him in presiding over the affairs of the Society during his term of office.

Adjourned.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, MARCH 25, 1905, AT 10 P.M.

The new Board of Directors was called to order by Mr. TOWNLEY. A quorum was present. The minutes of the last meeting were approved.

The business in hand being the election of officers for the ensuing year, the following officers, having received a majority of the votes cast, were duly elected:—

President: Mr. S. D. TOWNLEY.

First Vice-President: Mr. A. O. LEUSCHNER.

Second Vice-President: Mr. CHAS. S. CUSHING.

Third Vice-President: Mr. A. H. BABCOCK.

Secretaries: Messrs. R. G. AITKEN and F. R. ZIEL.

Treasurer: Mr. F. R. ZIEL.

Committee on the Comet-Medal: Messrs. W. W. CAMPBELL (*ex officio*), CHAS. BURCKHALTER, WM. H. CROCKER.

Library Committee: Dr. CRAWFORD, Miss O'HALLORAN, Miss HOBE.

Dr. CRAWFORD was appointed Librarian.

The President was authorized to appoint the members of the Finance Committee, and made the following selections:—

Finance Committee: Messrs. CHAS. S. CUSHING (Chairman), A. O. LEUSCHNER, WM. H. CROCKER.

The *Committee on Publication* is composed of Messrs. R. G. AITKEN (Chairman), S. D. TOWNLEY, B. L. NEWKIRK.

It was

Resolved, That in the event of any fund of the Society suffering a loss through any source, the amount so impaired shall be apportioned among all the Funds.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. S. D. TOWNLEY . . . . *President*
Mr. A. O. LEUSCHNER . . . . *First Vice-President*
Mr. CHAS. S. CUSHING . . . . *Second Vice-President*
Mr. A. H. BABCOCK . . . . *Third Vice-President*
Mr. R. G. AITKEN } . . . . *Secretaries*
Mr. F. R. ZIEL }
Mr. F. R. ZIEL . . . . *Treasurer*

Board of Directors—Messrs. AITKEN, BABCOCK, BURCKHALTER, CAMPBELL, CROCKER, CUSHING, HALE, LEUSCHNER, PARDEE, TOWNLEY, ZIEL.

Finance Committee—Messrs. CUSHING, LEUSCHNER, WM. H. CROCKER.

Committee on Publication—Messrs AITKEN, TOWNLEY, NEWKIRK.

Library Committee—Mr. CRAWFORD, Miss O'HALLORAN, Miss HOBE.

Committee on the Comet-Medal—Messrs. CAMPBELL (*ex-officio*), BURCKHALTER, CROCKER.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
(February, April, June, August, October, December.)

CONTENTS.

PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME XVII.

NUMBER 102.

1905.

SAN FRANCISCO:

PRINTED FOR THE SOCIETY.

1905.

[Entered at Post Office at San Francisco, Cal., as second-class mail matter.]

COMMITTEE ON PUBLICATION.

ROBERT G. AITKEN, Mt. Hamilton, Cal.
SIDNEY D. TOWNLEY, Ukiah, Cal.
BURT L. NEWKIRK, Berkeley, Cal.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. XVII. SAN FRANCISCO, CALIFORNIA, JUNE 10, 1905. No. 102.

VARIABLE STAR NOTES.

By ROSE O'HALLORAN.

The maximum of o *Ceti,* predicted for the 25th of February last, seems to have been of moderate range, but moonlight, lingering twilight, and low altitude hindered the close estimates of its light-changes sometimes obtainable. As stated in No. 100 of the *Publications A. S. P.*, the variable was brighter than 69 *Ceti* and dimmer than *Delta* of the same constellation on January 17th, and on January 24th was still of the same luster. On the 27th and 28th it approached nearer to the light of *Delta,* and on February 2d was equal to it. February 6th it was distinctly brighter than *Delta*, and with an opera-glass seemed somewhat brighter than *Gamma.*

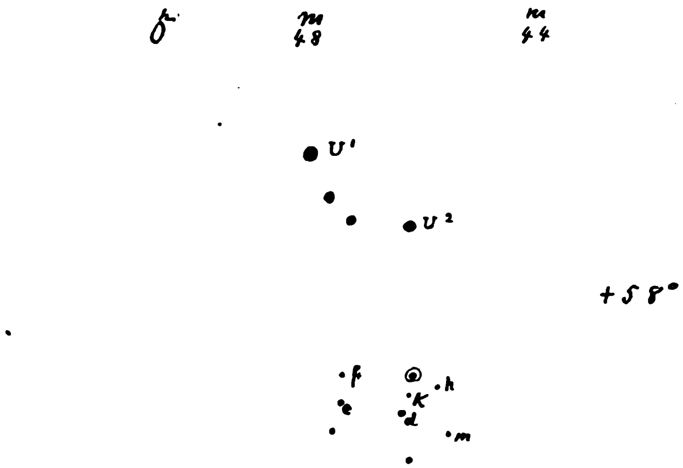
During the remainder of February it was compared with the two last-named stars, on the 7th, 12th, 21st, 23d, 25th, 28th, and on March 3d, 6th, and 8th, but no decrease was discernible before the crescent Moon interfered with satisfactory comparisons.

W Cassiopeiæ.

This variable is easily found not far south of U^2 *Cassiopeiæ,* and needs but a small instrument for observation of its variations, which are from about 8th to 12th magnitude. Its last decline from maximum to minimum was observed as follows:—

1904.

June 12. It is a magnitude or more brighter than *d.* No star of 8th magnitude is near enough for a satisfactory comparison.



Vicinity of *W Cassiopeiæ.*

June 24. Slightly decreased, but still brighter than any of the adjacent stars.

July 9, 15, 17. Equal to *d*.

July 31; Aug. 1, 11, 29. Less than *d*. Equal to *e*.

Sept. 2, 6, 12, 18. Between the light of *f* and *h*.

Sept. 27, 28. Equal to *h*.

Sept. 29; Oct. 3. 16. Less than *h*. Equal to *k*.

Oct. 19, 28. Between *k* and *m*. These two comparison-stars are scarcely of 11th magnitude, and in a four-inch lens are visible only on clear, moonless nights.

Oct. 30. Equal to *m*.

Nov. 2, 5. It seems slightly brighter than *m*.

Nov. 7, 8, 12. Equal to *m*.

Nov. 15. In moonlight barely discernible.

Nov. 27. Not discernible in slight haze. In the accompanying map the variable is the star within a small circle.

R Sculptoris.

The pink light of this southern variable made its identification easy on the 1st of last January, the date of its predicted

maximum. It was about 6.8 magnitude, or a few tenths less than *Tau*, classed as 6.5 in the Argentine General Catalogue. On the meridian it was discernible in an opera-glass.

R Leonis.

As the constellation of *Leo* has a high altitude in the evening hours at this season, the approaching maximum of *R Leonis*, predicted for June 24th, should be favorably observed. The irregularity to which its mean period of 312 days is subject may hasten or retard its highest range several days. The bright phases being discernible in an opera-glass, its red gleam is easily identified in the same field of view as the two stars of about 6th magnitude, numbered 18 and 19 in FLAMSTEED's catalogue. They are about two degrees northeast of *o Leonis*. The accompanying record shows that the variable has increased four magnitudes since January last. The magnitudes of the comparison-stars are those of the Potsdam *Publications* and the *Durchmusterung*.

1905.		
Jan.	27.	Brighter than 9.88. Less than 9.55.
Feb.	22.	Very slightly brighter than 9.05.
March	22.	Much brighter than 9.05. Nearly equal to 8.15.
March	26.	Equal to 8.15.
April	2.	No noticeable increase.
April	11.	Much brighter than 8.15, but less than 6.68. Probably not far from 7th magnitude.
April	22.	Of fully 7th magnitude. Brighter than 7.15, but not equal to 6.68.
April	25.	Equal to 6.68. Less than 5.90.
May	4.	Fully equal to 5.90. Faintly discernible with the naked eye.
May	8.	Brighter than 5.90. Less than 5.65.

SAN FRANCISCO, May 14, 1905.

PLANETARY PHENOMENA FOR JULY AND AUGUST, 1905.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

New Moon,	July	2,	9^h 50^m	A.M.
First Quarter,	"	9,	9 46	A.M.
Full Moon,	"	16,	7 32	A.M.
Last Quarter,	"	24,	5 9	A.M.
New Moon,	"	31,	8 3	P.M.
First Quarter,	Aug.	7,	2^h 16^m	P.M.
Full Moon,	"	14,	7 31	P.M.
Last Quarter,	"	22,	10 10	P.M.
New Moon,	"	30,	5 13	A.M.

The Earth is in aphelion,—that is, the Earth is at its greatest distance from the Sun,—at about 7 A.M. July 3d, Pacific time.

The third eclipse of the year occurs on the evening of August 14th, and is a partial eclipse of the Moon. It will be visible throughout the United States. The eclipse begins at 6^h 39^m P.M., Pacific time, shortly before sunset for far western points; its middle is at 7^h 41^m, and it ends at 8^h 43^m. The maximum obscuration is about one quarter of the Moon's diameter.

The fourth eclipse occurs on August 30th, and is a total eclipse of the Sun. The eclipse will be seen as partial in the early morning in that part of the United States east of the Rocky Mountains. The path of totality extends from the part of Canada north of Lake Superior eastward through Labrador, across the Atlantic, through Spain, the Mediterranean, and Egypt, ending in southern Arabia. The duration of totality is rather greater than usual, nearly four minutes for some localities, and there will be no difficulty in finding places in the path of totality suitable for observing-stations.

Mercury passed superior conjunction with the Sun June 24th and became an evening star. It will remain an evening star until August 29th, when it passes inferior conjunction with the Sun and becomes a morning star. It reaches its greatest eastern elongation, 27° 18'. August 2d, only two days before aphelion passage. This greatest elongation is therefore nearly the largest possible, but, as in the previous western elongation, the planet is south of the Sun and does not remain

above the horizon as long after sunset as it would otherwise. However, for nearly a month, from about July 10th to August 10th, the planet remains above the horizon an hour or more after sunset, an hour and twenty minutes for a few days before the time of greatest elongation. It may therefore be seen without great difficulty in the evening twilight on a clear day.

Venus is a morning star, reaching its greatest west elongation, 45° 44′, on August 6th. It rises from two and one half to three and one half hours before sunrise, the largest interval coming about the middle of August. It moves about 69° eastward among the stars from a point in *Taurus* a little south of the *Pleiades* through *Gemini* to the western boundary of *Cancer*. On July 17th it passes about 2° north of the first-magnitude red star *Aldebaran, α Tauri*. On the morning of July 4th it is in conjunction with *Jupiter*, passing 2½° south of the latter, and on August 14th it is in conjunction with *Neptune*, passing less than 1° south.

Mars is still in fine position for evening observation. It remains above the horizon until nearly 1 A.M. on July 1st, but sets a few minutes earlier each night, until at the end of August it sets shortly after 10 P.M. It moves during the two months 26° eastward and 6° southward from *Libra* into *Scorpio*. On August 26th it is about 3° south of *β Scorpii*, and at the end of the month it is about 5° north and west of *Antares, α Scorpii*. It will still be a prominent object, although even on July 1st its light will be only a little more than half as great as it was at opposition, and by the end of August it will be less than half as bright as it was on July 1st. On August 24th its distance from us will be about the same as the Earth's distance from the Sun.

Jupiter rises at about 2 A.M. on July 1st and at about 10:30 P.M. on August 31st. It is in *Taurus*, and moves about 9° east and 2° north from a point south of the *Pleiades* to a point about 5° north and west of the first-magnitude star *Aldebaran, α Tauri*.

Saturn is gradually moving to a place suitable for evening observation. It rises before 10:30 P.M. on July 1st, and before sunset on August 31st. It comes to opposition with the Sun about midnight on August 22d. It is retrograding, and moves about 4° west and south in *Aquarius*. The plane of the planet's

rings is much nearer the Earth than it was a year ago; and the minor axis is therefore much smaller than it was at that time. It is now only about one sixth of the major axis.

Uranus passed opposition with the Sun on June 24th and varies its time of setting from 4 A.M. on July 1st to about midnight on August 31st. It is in *Sagittarius*, a little north and west of the handle of the "milk-dipper" group.

Neptune is a morning object in *Gemini.*

OTTO WILHELM STRUVE.

By M. Nyrén.

[The following note on the life of the late Otto Struve has been translated from the original in the *Astronomische Nachrichten* (4013) because it seemed most appropriate to give our readers the words of one who was personally associated with him in the work of the Pulkowa Observatory.

In common with astronomers the world over, we hold the name and work of Otto Struve in high respect and honor.—R. G. A.]

Otto Wilhelm Struve, former Director of the Pulkowa Observatory, passed out of this life peacefully at Karlsruhe on the 14th of this month [April, 1905]. Thus closed a life rich in years, in work, in fulfillment. This life belongs to the history of Astronomy, and is inseparably connected with the history of the Pulkowa Observatory.

Born on the 7th of May [25th April], 1819, in Dorpat, where his father, Wilhelm Struve, held the position of Professor and Director of the University Observatory, Otto Struve completed his course in the gymnasium in his fifteenth year, but, because of his youth, was obliged to wait a year before being matriculated in the university of his native province.

When he took his degree in 1839 he had already been employed in the observatory for two years as his father's assistant. In the mean time the Central Astronomical Observatory for Russia had been founded at Pulkowa under the direction of W. Struve, and when it was opened for active work, Otto Struve and three other young scientists, G. Fuss,

E. SABLER, and C. A. F. PETERS, were appointed assistants to the director. This introduced him to the sphere of activity that was to bound his whole life work.

A few years later he was also appointed consulting astronomer to the General Staff and to the Hydrographic Department and, as such, had the opportunity of taking part in work in those lines. Having, in the capacity of astronomer and vice-director, for many years relieved his father of the heavier part of the burden of administering the observatory, he succeeded him as Director in 1862.

In the year 1887 he was therefore able to celebrate two jubilees—in honor of fifty years' service to the State, and of twenty-five years' service as Director. At the close of the year 1889 he resigned the directorate of the observatory and also his membership in the Academy of Sciences, with which he had been connected since 1852. STRUVE had desired to resign a year earlier, but, at the request of the Emperor, Alexander III, that he retain his position until after the celebration of the fifty-year jubilee of the observatory, in August, 1889, was persuaded to postpone his intention. For fully fifteen years, therefore, OTTO STRUVE enjoyed his *otium cum dignitate*, at first in St. Petersburg, and later, for his health's sake, in foreign lands, for the most part in Karlsruhe, where near relatives lived.

He was twice married; first to EMILIE DYRSSEN, of St. Petersburg, and later to EMMA JANKOWSKI, of Livonia. He survived his second wife, also, by many years.

It is not necessary to remind the readers of the *Astronomische Nachrichten* that the astronomical tradition in the STRUVE family did not die out with the first two generations.

The narrow limits of an obituary notice make it impossible to dwell, even briefly, upon the merits of OTTO STRUVE's scientific work. We shall only glance briefly at his work as Director of the observatory, which may be less well known to the world, but which occupied by far the greatest part of his time, and to which he gave his chief attention.

By reason of his personal association for half a century with every development of the institution founded by his father, it grew to be very dear to him, and the youthful zeal with which he devoted every energy to whatever concerned the

reputation and honor of Pulkowa did not forsake him even in his age. Only thus could he have succeeded in doubling, in the course of his directorate, the astronomical staff of the observatory as well as its instrumental equipment.

STRUVE's friendly personal relations with people of all classes aided him greatly in the matter of securing the means needed for these purposes, and he probably never encountered any question as to the propriety of the measures he advocated in any instance. Every one knew that, besides the interest of pure science, STRUVE never left out of sight the prestige of Russia, and especially of Pulkowa. To the sharpened penetration due to this vital interest in the observatory must also be ascribed the fact that he made scarcely a single mistake in the selection of his numerous associates.

In all co-operative undertakings in astronomical and closely related fields STRUVE took a lively interest, and was always ready to offer them all the assistance in his power. In evidence of this we may cite the great zone catalogue undertaken by the Astronomische Gesellschaft; the measurement of an arc of longitude in central Europe, of which he was a specially zealous advocate; also the preliminary deliberations concerning the photographic survey of the sky, the international meter commission, etc.

Over many of the conferences called to further these projects he presided as chairman. He served as president of the Astronomische Gesellschaft, of which he was a charter member, from 1867 to 1878. The Geodetic Survey of the great Russian empire, in so far as it depended upon the observatory, he advanced to the best of his ability. That geographical researches also appealed to him he proved by participating in the founding of the Imperial Geographical Society of St. Petersburg.

STRUVE provided with a father's care for those connected with the observatory, and could always devise means when needed to improve their material position. He did his utmost, too, to make the social life of our little isolated community as agreeable as possible.

By reason of his active association with other men, foreigners as well as Russians, STRUVE won for himself an unusually large circle of friends. That he did not lack enemie

as well is not to be wondered at, in view of his striking personality. A large number of astronomers from the New World as well as from the Old honored him with visits during his directorate. As a matter of course, the visits from Russians were the most numerous. Nearly all of our professors of astronomy of the last few decades have been graduated from the school of Pulkowa, and at every opportunity have shown their deep, unchanging reverence for the head of the institution in which they began their scientific work.

PULKOWA, April, 1905.

NOTES FROM PACIFIC COAST OBSERVATORIES.

Tests of the Snow Telescope.

As the success of the solar work on Mt. Wilson depends in large measure upon the quality of the images given by the Snow telescope, the tests of this instrument made since the close of the rainy season have proved of great interest to the members of the observatory staff. From previous experience it was recognized that the selection of a suitable design for the telescope-house is of vital importance, in view of the difficulty of preventing unequal heating of the air in the path of the beam. Again, it was a question whether the cœlostat would prove to be sufficiently high above the ground to escape the disturbing effect of the heated air at low levels. The serious expense involved in the construction of larger piers had limited the height of the cœlostat to about twenty feet, although observations of the Sun made from a tree with a small telescope indicated that a much greater elevation would probably be advantageous. Finally, the distortion of the mirrors by the Sun's heat was known to be a serious source of danger.

While it is still too early to express final conclusions, or to give the details of the tests, it may be said that the performance of the telescope has decidedly surpassed our expectations. The louver construction of the telescope-house seems to afford the desired protection against heating, and the possibility of raising and lowering the inner canvas walls has proven of great service. Ordinarily the best definition is obtained when the inner wall on the side toward the Sun is raised, and the wall on the opposite side of the house is lowered. Many comparative tests of the seeing have been made with the aid of a 3¼-inch visual telescope, mounted on a tripod support near the cœlostat. In all cases the image has been no less sharply defined with the Snow telescope than with the small refractor—cer-

tainly a most satisfactory result. On many occasions the solar image has been beautifully sharp, and good photographs of calcium and hydrogen flocculi have been made with a spectroheliograph constructed for temporary use, pending the completion by the Zeiss Optical Works of large prisms for the permanent spectroheliographs. Professor BARNARD states that the Moon, as observed one night with the Snow telescope, was as well defined as he had ever seen it with the 40-inch Yerkes refractor. Star-images are also excellent, except when the instrument has been used during the late afternoon in work on the Sun. In such a case the mirrors do not cool down to a normal condition until late in the evening, and during the transition state the star-images are curiously distorted.

It had been anticipated that difficulty would be experienced from changes in the focal length of the telescope, due to heating of the mirrors, and this has proved to be the case. Except in the early morning hours, however, the change in focal length is small and of little importance. Electric-heating apparatus is now being provided for the purpose of maintaining the mirrors during the night at such a temperature as to give the least change of figure when they are exposed to the Sun in the morning.

GEORGE E. HALE.

SOLAR OBSERVATORY, MT. WILSON, CAL.

GIFT FROM MR. D. O. MILLS.

I take great pleasure in announcing that MR. D. O. MILLS has provided means for continuing the work of the D. O. Mills Expedition to the Southern Hemisphere for a period of five years additional to that covered by the original programme. This generous action provides also for suitable addition to the equipment of the observatory now located on the summit of San Cristobal, near Santiago, Chile; for the salaries and traveling expenses of the astronomer in charge and two assistants; and for running expenses.

Important items of equipment will be spectrographs of lower dispersion in order that the determination of radial velocities of stars in the southern sky may be extended to considerably fainter stars than can be attacked with the present powerful three-prism spectrograph.

It is hoped that the results of this second period of work will form a valuable contribution to the Sidereal Problem, for the region of the sky not visible from the northern observatories.

Mr. MILLS's continued interest in this branch of astronomy is a most encouraging factor in the prosecution of the work.

W. W. CAMPBELL.

THE PERSONNEL OF THE CROCKER ECLIPSE EXPEDITION FROM THE LICK OBSERVATORY.

It is expected that the three eclipse expeditions provided for by the generosity of Mr. WM. H. CROCKER will be located respectively in the immediate vicinity of Cartwright, Sandwich Bay, Labrador; in the Daroca-Ateca-Almazan region of northeastern Spain; and at Assuan, Egypt.

The Labrador expedition will be in charge of Acting Astronomer HEBER D. CURTIS, whose chief assistant will be Professor JOEL STEBBINS, of the Astronomical Department of the University of Illinois. Dr. STEBBINS was a fellow in the Lick Observatory during the years 1902-1904. Mrs. CURTIS and Mrs. STEBBINS will accompany the expedition. Dr. WILFRED T. GRENFELL, whose unselfish work as a practical missionary on the Labrador coast is widely and favorably known, has promised to bring his ship to the eclipse path two or three days before the date of the eclipse, in order that he and three or four of his scientific staff may assist Dr. CURTIS in the observations.

The Spanish expedition will be in charge of Director CAMPBELL, who will be accompanied by Astronomer PERRINE. In this connection I take pleasure in saying that Professor PERRINE's work on the expedition will be rather in the capacity of associate than assistant, a *status* to which his successful work at the Sumatra eclipse entitles him. Mrs. CAMPBELL and Mrs. PERRINE will accompany the expedition. Professor THOMAS E. McKINNEY, formerly a graduate student in the University of Chicago, and now Professor of Mathematics and Astronomy in Marietta College, Ohio, will be with the expedition in the capacity of assistant. It is hoped that many astronomers and physicists of this country and Europe will join the expedition in eclipse week to take part in the observations.

The Egyptian expedition will be in charge of Astronomer HUSSEY, who will be assisted by Professor ROBERT H. WEST, formerly a student of Professor YOUNG in Princeton University and now Director of The Observatory, Syrian Protestant College, Beirut, Syria. Mrs. HUSSEY will accompany the expedition. Captain H. G. LYONS, R. E., Director-General of the Survey Department, Egypt, has most kindly arranged for the coming of several gentlemen to Professor's HUSSEY'S station during eclipse week to take part in the observing programme.

In making preliminary arrangements for these expeditions invaluable assistance has been rendered by government officials in Newfoundland, in Spain, and in Egypt. Full acknowledgment of this help will be made later.

The members of the Egyptian expedition sail from New York on June 15th, of the Spanish expedition on July 6th, and of the Labrador expedition on July 8th. It is planned that the Labrador and Spanish stations shall be reached about July 23d, and the Egyptian station about August 8th. The constant clear weather expected at the latter station should permit the rapid and continuous work of mounting, adjusting, and testing the apparatus.

The general scientific plans of the expedition were published nearly a year ago in this journal. The instrumental equipment will have been completed in the Lick Observatory shops about June 1st, quite strictly in accordance with the original programme,—in a considerable measure due to the kindness of other institutions in loaning valuable pieces of apparatus. These loans will be fully acknowledged later. The equipment will leave Mt. Hamilton on June 5th for railway shipment to New York, and thence by steamer to the three countries.

During the absence of Director CAMPBELL the Lick Observatory will be in charge of Astronomer TUCKER, who has been appointed Acting Director by the Board of Regents of the University of California for this period.

W. W. CAMPBELL.

COMET *a* 1905 (GIACOBINI).

The first comet of the year 1905 was discovered by GIACOBINI on the 26th of March. Telegrams from the Lick and

Harvard College observatories giving the discovery position were received at the Students' Observatory the following day. Professor AITKEN secured his first observations on the evenings of the 27th and 30th, cloudy weather prevailing at Mt. Hamilton on the 28th and 29th. No further observations from Eastern observatories were received in the mean time. Professor AITKEN's observations were kindly telegraphed to the Students' Observatory by the Director of the Lick Observatory.

The three positions referred to above are as follows:—

March 26.3212	5^h	44^m	$14^s.0$	$+10°$	$56'$	$56''$ GIACOBINI (Nice).
27.6692	5	48	54 .8	+12	35	43 AITKEN (Mt. Hamilto
30.7185	5	59	59 .5	+16	19	11 AITKEN (Mt. Hamilto

Just previous to the discovery of this comet, Professor LEUSCHNER had made an adaptation of his "Short Method"[1] to the direct computation of a parabola. Applying his criterion to ascertain whether or not a parabola would fall within the limits of possible solution, it was found that a parabola could be passed through these observations. Accordingly, his parabolic method was applied at once, and the following elements obtained:—

PRELIMINARY ORBIT—ELEMENTS.

$$T = 1905 \text{ April } 3.7312 \text{ Greenwich M. T.}$$

$$\left.\begin{array}{l} \Omega = 156 \quad 45.5 \\ i = \ \ 40 \quad 51.4 \\ \omega = 357° \quad 49'.6 \end{array}\right\} 1905.0$$

$$\log q = 0.04981$$

The residuals for the first and third places are:—

	I	III
$\Delta\alpha \cos\delta =$	$\pm 0^s.0$	$-0^s.1$
$\Delta\delta =$	$+0'.04$	$+0'.04$

A short ephemeris derived from these elements may be found in *Lick Observatory Bulletin*, No. 73.

This ephemeris held so well that it was considered unnecessary to compute a second orbit until the comet had covered

[1] *Publications of the Lick Observatory*, Vol. VII, Part I.

an arc of some length. A second orbit was, therefore, based upon the following observations by Professor AITKEN:—

1905. Greenwich M. T.	α Comet's Apparent.	δ
March 27.66920	5^h 48^m $54^s.85$	$+12°$ $35'$ $42''.9$
April 7.69426	6 32 29 .42	+25 47 09 .8
April 23.72829	7 53 37 .34	+41 05 07 .5

The computation was made by Professor LEUSCHNER's method of determining differential corrections to the preliminary orbit. Starting values of the residuals for the first and third dates were derived from the geocentric distance, and the heliocentric velocities at the middle date on the basis of the preliminary orbit and from the observed position for the middle date corrected for parallax and aberration, with the following result:—

$\Delta\alpha \cos\delta$	$-0'$ $56''.0$	$+6'$ $20''.2$
$\Delta\delta$	-1 27 .5	$+7$ 10 .2

As the computation was arranged so as to remove the residuals in α and throw any deviation from a parabola into the declinations of the first and third places, it was evident from these residuals that a second approximation would give no better result. As a check, however, on this conclusion, and for the purpose of producing, if feasible, a parabolic ephemeris which would represent future observations as satisfactorily as possible, a second approximation to a parabola was made in such a way as to throw all the deviation into the first declination. This plan was found more convenient than a distribution of the deviation between the right ascension and the declination. The resulting residual in δ was $+67''.8$.

This residual is larger than can be accounted for by the combined effect of the errors of observation in the three given positions.

Although parabolic solutions were unnecessary in this case, they were carried through in deference to the existing tradition among astronomers to satisfy if possible the observations of a new comet by a parabola first, and to attempt an ellipse only when it can be definitely shown that the orbit is not parabolic. Fortunately, several parabolic solutions can be made by Pro-

fessor LEUSCHNER's method very quickly; they therefore involved but little loss of time.

As the observations could not be satisfied by a parabola, another set of elements was derived from the residuals of the first parabola without hypothesis regarding the eccentricity, by means of the "Short Method" (cf. *Lick Observatory Bulletin*, No. 55). They are as follows:—

ELEMENTS.

$$
\begin{aligned}
T &= 1905 \text{ April } 4.04387, \text{ Greenwich M. T.} \\
\left.\begin{aligned}
\omega &= 358^\circ\ 12'\ 16''.9 \\
\Omega &= 157\ \ 25\ \ 27\ .3 \\
i &= \ \ 40\ \ 13\ \ 02\ .0
\end{aligned}\right\} & \ 1905.0 \\
\phi &= \ \ 76\ \ 01\ \ 46 \\
\log a &= 1.576167 \\
\log e &= 9.986960 \\
q &= 1.114708 \\
\mu &= 15''.3376
\end{aligned}
$$

The period is about 231 years.

An ephemeris extending to June 3d may be found in *Lick Observatory Bulletin*, No. 76.

This orbit represents an observation by Professor AITKEN on the night of May 21st, very closely. The residuals are:—

$$\Delta\alpha \cos\delta = +\ 0^s.32 \qquad \Delta\delta = +\ 3''.5$$

Professor AITKEN, in sending this observation, says: "The wind was swaying the telescope, making the measures difficult, so that fully half of the residual may be counted as error of observation."

In passing, it may be well to point out some of the salient features of Professor LEUSCHNER's new method. Besides the rapidity with which a general orbit may be computed, there may be noted the readiness with which passage may be made from a parabola to an ellipse, and *vice versa;* the small amount of labor involved in making successive approximations in order to remove residuals completely; the ease with which residuals (in the case of a parabola) may be distributed at will among any of the six coordinates; and, finally, the perfect perspicuity of the whole method, which enables the computer to see the

meaning of every step in the computation, nothing being hidden in abstruse analytical development.

It may be of interest to add that in this computation the "constants for the equator" were computed in advance of the elements. The latter were computed by data furnished by the former, a process which is much simpler than the usual method employed.

RUSSELL TRACY CRAWFORD.
JAMES D. MADDRILL.

BERKELEY ASTRONOMICAL DEPARTMENT.

THE RESIGNATION OF ASTRONOMER HUSSEY.

I regret to announce that Astronomer W. J. HUSSEY of the Lick Observatory staff has resigned his position, to take effect on October 1, 1905, in order to accept appointment as Professor of Astronomy in the University of Michigan and Director of the Detroit Observatory. In accepting this resignation, the Board of Regents of the University of California unanimously passed the following resolution:—

"*Resolved*, That in accepting the resignation of Astronomer W. J. HUSSEY, of the Lick Astronomical Department, the President and the Board of Regents of the University of California beg to acknowledge his faithful and efficient services during the past nine and a half years. His discovery of thirteen hundred double-star systems, his study of these and other systems, and his observations of many of the satellites in the solar system are important factors in the history of the Lick Observatory. We trust that his work in the position which he assumes in the University of Michigan will continue strongly to promote the interests of astronomical science."

Professor HUSSEY's present colleagues wish him continued success in his new position.

It is understood, I believe, that the observatory at Ann Arbor is to be modernized through reconstruction on a considerable scale.

W. W. CAMPBELL.

APPOINTMENT OF DR. CURTISS ON THE STAFF OF THE ALLEGHENY OBSERVATORY.

Dr. RALPH HAMILTON CURTISS, who has been connected with the Lick Observatory for the past four years, first as an assistant on the Crocker Eclipse Expedition to Sumatra, for the next three years as Fellow in the Lick Observatory, and dur-

ing the past half-year as Carnegie assistant in the Lick Observatory, has recently been appointed Assistant Astronomer in the Allegheny Observatory.

At the close of the last calendar year Mr. CURTISS received the degree of Doctor of Philosophy from the University of California, as a result of special studies made in the Departments of Astronomy, Physics, and Mathematics in Berkeley, and of Astrophysics in the Lick Observatory. His principal duties in the Allegheny Observatory will be in the line of astrophysical investigations under the direction of Professor FRANK SCHLESINGER.

W. W. CAMPBELL.

HONORS FOR PROFESSOR PERRINE.

At the May meeting of the Board of Regents of the University of California, Assistant Astronomer CHARLES D. PERRINE, of the Lick Observatory staff, was promoted to the position of Astronomer in the Lick Observatory, in recognition of his extremely fruitful work in several lines of astronomical research.

At the recent commencement of Santa Clara College, the oldest institution of learning on the Pacific Slope, the honorary degree of Doctor of Science was conferred upon Professor PERRINE.

W. W. CAMPBELL.

SMITHSONIAN EXPEDITION TO MT. WILSON.

Mr. C. G. ABBOT, Aid Acting in Charge of the Smithsonian Astrophysical Observatory, has arrived at Mt. Wilson, and is installing apparatus for the study of the solar constant. Mr. ABBOT is assisted in the work by Mr. L. R. INGERSOLL, of the University of Wisconsin. The object of the expedition, which has been sent out under the direction of Secretary LANGLEY, is to determine whether the solar-constant measurements exhibit such variations as have been observed at the Smithsonian Observatory during the last few years, and whether, if any variations occur, they will simultaneously be noted in Washington, where the observations are to be continued as usual. Pyrheliometer readings, which are now being made throughout the day, indicate that the atmospheric conditions on Mt. Wilson are likely to prove very favorable for the work. Buildings and pier for the spectrobolometer and other instruments have

already been constructed, and within a short time the recording instruments will be in operation. The expedition will remain at Mt. Wilson about three months.

GEORGE E. HALE.

SOLAR OBSERVATORY, MT. WILSON, CAL.

WATER SYSTEM FOR THE SOLAR OBSERVATORY.

A pumping-plant, consisting of a triplex pump, driven by a five-horse-power electric motor, a receiving tank of 20,000 gallons capacity, a pipe-line 2,100 feet in length, with a rise of 325 feet, a storage reservoir of 30,000 gallons capacity, a distributing-pipe supplying all the buildings of the observatory, and an electric-power line from the power-house to the pump, is now under construction on Mt. Wilson. It is expected that the system will be in operation within two weeks, though the large reservoir will not be completed until later. A special fire-pump, connected with a 500-gallon tank containing a very effective fire-extinguishing fluid (and also connected with the water reservoir), will afford protection for the Snow telescope-house and the other buildings.

GEORGE E. HALE.

SOLAR OBSERVATORY, MT. WILSON, CAL.

ORBITS OF THE SIXTH AND SEVENTH SATELLITES OF *JUPITER.*

The sixth satellite was under observation from December 3, 1904, to March 22, 1905, inclusive, and the seventh satellite from January 2, to March 9, 1905.

The writer computed approximate orbits for both of these satellites, but before entirely satisfactory representations of the observations were secured it was necessary to discontinue this work and prepare for the coming eclipse.

Dr. F. E. Ross, formerly Fellow in the Lick Observatory and now in the Carnegie Institution of Washington, undertook, under the direction of Professor NEWCOMB, the determination of more accurate orbits for these satellites. He has completed the orbit for the sixth satellite, which represents the observations as closely as can be expected. According to this orbit, the sixth satellite is moving about *Jupiter* in the *same direction* as the five inner satellites, and in a period of 242 days. Its eccentricity is considerable, however, amounting to 0.16, and the inclination of its orbit to the plane of *Jupiter's* equator is

very large, about 30°. Its mean distance from *Jupiter* is abo seven million miles.

The orbit for the seventh satellite is not yet finished. Th computed by the writer gave a period of two hundred da with a mean distance of six million miles from the prima and an eccentricity of 0.36. Like the sixth satellite, the or of the seventh is inclined at an angle of about 30° to the pla of *Jupiter's* equator. The direction of motion, howev appears to be *opposite* to that of the sixth (and the five inn satellites). Should this prove to be the case, these two bod will form an extremely interesting pair; for in that case th orbit-planes almost coincide in space.

The disturbing action of the Sun on these two satellites w be very great.

C. D. PERRINE.

May 28, 1905.

TWO NEW VARIABLE STARS.

The stars numbered 564 and 565 in the Leipzig II zone the Astronomische Gesellschaft were used as comparison-st in photographic observations of the VI and VII satellites *Jupiter*, and are found to be variable. Their positions 1875.0 are as follows:—

No. 564	α $1^h\ 24^m\ 46^s.79$	δ $+7°\ 51'\ 23''.3$	Mag.
565	1 24 55 .30	+7 38 25 .5	

These stars appear on the plates of January 25th, 26th, 27 and 28th. Rough estimates of their magnitudes are giv below:—

	P. S. T.	Plate No.	Star No. 564.	Star No. 565
January 25	$8^h\ 50^m$	1408	9.0	10.5
26	8 6	1410	9.0	9.5
26	9 9	1411	9.0	9.5
27	7 26	1414	9.7	9.0
27	8 44	1415	9.2	9.4
27	9 42	1416	9.2	9.4
28	6 58	1418	9.0	9.3
28	7 37	1419	9.0	9.5
28	8 16	1420	9.0	9.5

So far as I am aware, these stars were not previously know to be variable. It is not yet possible to determine magnitud of stars on these photographs with any great degree of refin ment.

C. D. PERRINE.

May 27, 1905.

ζ *Scorpii* a Short-Period Binary.

The two fifth-magnitude components that form the close double-star Σ 1998 (= ζ *Scorpii*) have been known to be in orbital motion since the time of Struve. Careful measures have therefore been made of this system by many double-star observers during the past seventy-five years, and several attempts have been made to compute the true orbit.

It has generally been assumed that the orbit is nearly circular and highly inclined toward the line of sight. This view was taken by Schorr in his thorough discussion of the data in 1889 ("Inaugural Dissertation zu München"), and by See in 1895 ("Evolution of the Stellar Systems"), the results obtained by these two computers being very similar. They give values of 105 and 104 years, respectively, for the periodic time, 0.12 and 0.13 for the eccentricity, and 68° and 70° for the inclination.

My measures of this pair during the past seven years indicate a very different form of orbit, for they give the following residuals from the places computed from See's elements:—

Date.	(o - c) $\Delta\theta$	$\Delta\rho$
1898.17	+ 1°.2	+ 0″.03
1899.35	+ 3 .3	— 0 .05
1901.47	+ 9 .9	— 0 .19
1903.51	+ 27 .9	— 0 .29
1904.40	+ 55 .3	— 0 .37
1905.30	+100 .9	— 0 .34

From these measures it appears that the motion instead of being slow is now very rapid, and that the pair is now a difficult one to observe with the 36-inch telescope instead of being an easy object for an instrument of small aperture.

Plotting these measures and all others that were available, I found it possible to satisfy them with an apparent ellipse that yielded a very eccentric orbit with a period of only 44.5 years. To do this it was necessary to change by 180° the angles given by observers up to the year 1862. But the two components are so nearly equal in magnitude that this may be done legitimately. In fact, both Schorr and See made such correction to Herschel's angle.

The details of my work are given in a forthcoming *Lick Observatory Bulletin.* The elements now computed are as follows:—

True Orbit.		Apparent Orbit.	
$P =$	44.5 years	Length of major axis	1″.464
$T =$	1905.4	Length of minor axis	0 .802
$e =$	0.767	Dist. of star from center	0 .561
$a =$	0″.701	Angle of major axis	11°.0
$\omega =$	352°.6	Angle of perihelion	13 .5
$\Omega =$	20 .4	Position angles increasing.	
$i =$	±29 .1		

These results are considered as approximate only. The apparent motion of the companion will be so rapid during the next few years that data will soon be available for a more complete discussion of the theory of the system than seems advisable at present.

R. G. AITKEN.

May 29, 1905.

NEW COMPANIONS TO THREE STRUVE DOUBLE STARS.

In the course of my systematic search for new double stars I have recently found additional close companions to the well-known pairs, Σ 419, Σ 1000, and Σ 1823. The mean results of my measures of the new and old companions are as follows:—

			Σ 419.		
1905.13	347°.4	0″.44	7.4 — 9.8	2^n	B and C. New.
1905.13	73°.6	3″.08	7.2 — 7.3	2	A and B = Σ 419.
			Σ 1000.		
1904.95	313°.8	0″.27	8.2 — 8.5	2^n	A and B. New.
1904.94	66 .8	22 .29	8.0 — 9.0	1	AB and C = Σ 1000.
			Σ 1823.		
1905.34	239°.2	0″.21	9.0 — 9.5	2^n	A and B. New.
1905.34	149 .6	3 .49	8.7 — 9.7	2	AB and C = Σ 1823.

My measures of Σ 419 and Σ 1000 give practically the same results as those obtained by STRUVE seventy-five years earlier. STRUVE's measure of Σ 1823 is:—

1830.0 156°.1 3″.35 8.5 — 9.5.

May 23, 1905.

R. G. AITKEN..

NOTE ON SECCHI'S COMPANION TO Σ 2481.

In 1856 SECCHI found that the smaller star of the pair Σ 2481 was itself a close double. It was a very difficult object with his telescope, and he was able to measure it on only two nights. A few measures were made by other observers in the twenty-five years that followed, and these indicated, rather uncertainly, a slow retrograde motion. From 1881 on, the star seems to have been entirely neglected until 1897, when it was placed on my regular observing-list. I have followed it carefully for the past eight years, and can now say certainly that the fact of orbital motion is established and that the period is probably not much greater than fifty years.

Unfortunately the early measures are not only few in number but also very discordant. It is therefore impossible to compute even an approximate orbit at this time, though the observed arc is fully 340°. It will probably be necessary to wait at least twenty years for data to define the apastron end of the apparent ellipse.

The present note is written to call the attention of double-star observers to this pair, which deserves annual measurement. So far as I can discover, the following list includes all the existing observations:—

MEASURES OF Σ 2481 BC = SECCHI.

1856.832	93°.4	0″.4	1^n	SECCHI.
59.610	98 .2	0 .4	1	SECCHI.
66.74	83 .4	0 .45(est)	1	O. STRUVE.
76.13	84 .8	0 .49	4	SCHIAPARELLI.
77.31	69 .8	0 .37	2	DEMBOWSKI.
80.46	91 .1	0 .37	5	SCHIAPARELLI.
81.57	61 .9	0 .33	3	HOUGH.
97.85	243 .3	0 .17	2	AITKEN.
98.60	211 .1	0 .17	2	AITKEN.
1899.69	187 .9	0 .16	3	AITKEN.
1900.61	148 .2	0 .15	1	AITKEN.
01.40	132 .8	0 .14	2	AITKEN.
01.89	137 .1	0 .15	1	AITKEN.
03.71	127 .2	0 .23	3	AITKEN.
04.44	120 .0	0 .22	2	AITKEN.
05.29	114 .3	0 .24	1	AITKEN.

May 22, 1905. R. G. AITKEN.

TIME-SIGNALS FROM WASHINGTON.

The time-signals sent out by the United States Naval Observatory on May 3d in honor of the International Railway Congress were sucessfully received at the Students' Observatory of the University of California. A special set of time-observations was made by Dr. CRAWFORD on the evening of May 3d, before and after receiving the signals. A large number of these signals were measured on the chronograph, with the result that the Washington midnight signal was found to have been registered at Berkeley at $8^h\ 59^m\ 59^s.92$, P. S. T. This result is based on the adopted longitude of Berkeley, $8^h\ 9^m\ 2^s.72$ West of Greenwich. The Berkeley Astronomical Department is indebted for courtesies received on this occasion to Superintendent F. H. LAMB of the Western Union Telegraph Company, and to Vice-President LOUIS GLASS of the Pacific States Telephone and Telegraph Company.

A. O. LEUSCHNER.

BERKELEY ASTRONOMICAL DEPARTMENT, May 24, 1905.

Dr. A. F. GILLIHAN, for two years Assistant in Practical Astronomy in the Berkeley Astronomical Department of the University of California, has resigned his position to devote himself exclusively to the practice of medicine. The position is as yet unfilled. A qualified graduate student of at least one year's standing would be acceptable for the position.

A. O. LEUSCHNER.

BERKELEY ASTRONOMICAL DEPARTMENT.

GENERAL NOTES.

The Constant of Aberration.—The *Astronomical Journal* No. 571 contains an article by C. L. DOOLITTLE on "The Constant of Aberration." Professor DOOLITTLE gives the definitive results of eight series of observations for the determination of the constant of aberration, extending from 1889 to 1904. The first three series were made at the Sayre Observatory and the balance at the Flower Observatory. Altogether 15.363 pairs of stars were observed, and the final value deduced for the aberration constant is 20″.540. Professor DOOLITTLE remarks that no reasonable changes in the weighting of the results of the different series will alter this result more than 0″.01. One begins to wonder sometimes where the value of the aberration constant is going to stop. For a great many years STRUVE'S value, 20″.445, was used. In 1896 the Paris Conference adopted the value 20″.47 and Professor YOUNG gives this value in his work on General Astronomy with the remark that it is still uncertain by 0″.01 or 0″.02. In 1903 Dr. CHANDLER made an exhaustive investigation of this subject and expressed the conviction that the " real value of this much-disputed constant is likely to be found near or slightly above 20″.52."

And now, in 1905, Professor DOOLITTLE, as a result of more than fifteen thousand determinations of this constant, announces a value of 20″.54.

In the same number of the *Journal* mentioned above the committee on variable stars of the Astronomische Gesellschaft gives a list of fifty-eight new variable stars to which definitive designations have been assigned.

The *Astrophysical Journal* for March contains two interesting articles by Professor GEO. E. HALE, entitled, "A Study of the Conditions for Solar Research at Mount Wilson, California," and "The Solar Observatory of the Carnegie Institution at Washington." The latter article is illustrated by some excellent views.

The following notes have been taken from recent numbers of *Science*:—

"The Astronomical Observatory built by the late Dr. HENRY DRAPER at Hastings-on-Hudson in 1860 and used by him for his researches until his death in 1882, was destroyed by fire on March 31st. The telescopes and other instruments were removed to Harvard University in 1886, where, under the direction of Professor E. C. PICKERING, Mrs. HENRY DRAPER established the Draper Memorial Fund, but photographic negatives and other material of historic interest have been destroyed."

"A teaching observatory will be established by the Ontario government at the University of Toronto. Dr. C. A. CHANT expects to visit the observatories of the United States to study their plans and mehods."

Mr. PERCIVAL LOWELL has established a liberally endowed fellowship, to be known as the Lawrence Fellowship for the Department of Astronomy at Indiana University. By the terms of the endowment the Fellow is appointed by the department, but the appointment is subject to the approval of the founder. A Lawrence Fellow shall be given an opportunity for astronomical research at Lowell Observatory, and to prepare a thesis on some astronomical subject agreeable to the Director, and the Fellow Mr. JOHN C. DUNCAN, '05, has received the appointment for 1905-1906.

The Fifth Satellite of Jupiter.—In number 100 of these *Publications* Professor BARNARD published a reply to my criticism (*A. S. P.*, No. 98) of Miss DOBBIN'S computation of the orbit of the fifth satellite of *Jupiter.*

It seems almost incomprehensible that a computer, who has the best reason in the world for not including other observations,—namely that there were no other observations of a similar kind,—should fail to state that fact, and should instead try to justify the course pursued, of using only one person's observations, on such indefinite grounds as gaining "homogeneity," avoiding "personality of different observers," etc. It should be the aim of the computer to

eliminate rather than to *avoid* personalities of the observers,—or systematic *errors*, as I prefer to call them. That the systematic errors of competent observers in measuring the position-angle and distance of a satellite could be of such magnitude as to mask the quantities sought seems to me highly improbable, and neither Professor BARNARD nor Miss DOBBIN has shown in any way that this could be so. I for one am unwilling to believe without proof that such could be the case.

Professor BARNARD objects to my citation of Mr. HINKS's determination of the solar parallax. That the cases are not parallel is readily admitted. I had in mind in particular Mr. HINKS's remarks near the bottom of page 726 (*M. N.*, June, 1904), where he states: " . . . while the quite unexpected large errors in the Algiers plates, *taken with a refractor of standard pattern, cannot fail to inspire many stimulating doubts as to the absolute value of results obtained with one instrument alone.* At the same time elimination of the larger part of the systematic errors, which seems to have been achieved, assures us at once of the practicability of making a general solution, and of the difficulty of treating the results of any one observatory apart from the others." (Italics mine.) These words were written concerning a specific problem, and that they do not apply to all problems goes without saying. I gave this as an *illustration* of the benefit to be derived from comparing, for the purpose of detecting and eliminating systematic errors, observations made at different places.

Professor BARNARD cites Dr. CHANDLER's determination of the orbits of the companions to Comet V 1889 as an illustration of the case of using the observations of only one man. A brief statement is as follows, the quotations being from Dr. CHANDLER's article (*A. J.*, Nos. 236-237):—

"The companion *C* was by far the most continuously and generally observed. and indeed the only one in which there are adequate means for the determination of a satisfactory orbit. With a few exclusions for mistakes or incompleteness, we have 155 positions, covering an interval of 114 days, contributed by sixteen observatories. Of these the Lick series, by BARNARD, constitutes over one third, begins earlier, ends later, and is more continuous than any other. It has a

superior degree of excellence as to smallness of accidental error; and notwithstanding some small peculiarities that will appear later in the discussion, we may be warranted in assuming that the advantages of exceptional atmosphere and aperture reduce to a minimum the chance for varying systematic error, dependent on the changing aspect of this faint object during its long season of visibility. I have, therefore, unhesitatingly chosen this series as a zero of reference for the constant errors of the other observations, and have also given an independent solution based on the Lick observations alone, *for comparison, with, and re-enforcement of,* the conclusions drawn from the general solution." (Italics mine.) It is seen from this that the other observations were not rejected, and the solution from BARNARD's observations was merely used to re-enforce the conclusions drawn from the general solution. As far as I am able to find, Dr. CHANDLER makes no statement concerning the relative merits of the results of the two solutions. Instead of being an example of "one-man" work, Dr. CHANDLER's article seems to me to be a most excellent example of the combination of observations made at different observatories.

For the companion *B* there were twenty-three observations made at the Lick Observatory and six at Vienna. Concerning these Dr. CHANDLER says: "In attempting to find the most probable orbit of *B* from a discussion of the above material, we meet two obstacles to a satisfactory solution. The first arises from the serious discordances between the Vienna and the Lick observations, already noticed in a less degree in those of companion *C* (p. 157). . . . After expending much time and labor in futile experiment with various hypotheses, I am forced to the conclusion that the only way to meet the first difficulty—since the Vienna observations are not numerous enough to be independently discussed—is to assume the correctness and homogeneity of the Lick series, with the 36-inch, and to base the calculations on them alone."

I am indeed surprised that Professor BARNARD should quote this instance to uphold his procedure. There is as much difference between the two cases as there is between day and night. Dr. CHANDLER rejected the Vienna observations only after spending much time and labor in an attempt to reconcile the two series, while Professor BARNARD would reject to

begin with all other observations for fear of confusion that may arise from systematic errors. It should go without saying that no general conclusions can be drawn from Dr. CHANDLER'S procedure in this case.

Professor BARNARD cites a second case to uphold his method. It is the determination of corrections to the elements of the orbit of the satellite of *Neptune*, by Professor ASAPH HALL (*A. J.*, 441). Professor HALL computed the orbit of this satellite in 1883, and later chose a series of observations made in 1897 and 1898 by Professor BARNARD, with the 40-inch Yerkes telescope, to test the accuracy of the elements. No statement is made by Professor HALL of the reasons he may have had for not including other observations. No other series contains anywhere near as many observations as BARNARD'S, and it may be that Professor HALL considered all others as sporadic. If so, that would be sufficient ground for rejecting them, but others might legitimately differ with him as to the sporadicalness of the observations. Or again, he may have considered that the time was not ripe for making a definitive discussion of the orbit, or it may be that he did not care to enter into the amount of labor that a complete discussion would call for. My own opinion is that Professor HALL'S main object was to test the orbit determined by him and this could be done by means of one series of observations as well as by many, and it was, perhaps, not incumbent upon him to state the reasons for proceeding as he did. It is not always necessary for a person to state the reasons why he has not done something which he might have done; but if he does, the reasons should be good ones.

In writing the criticism I had no intention whatever of casting reflection or suspicion upon Professor BARNARD'S observations. It has been shown a number of times that he makes micrometric measures of a high degree of excellence and that his observations are in general particularly free from both accidental and systematic errors. My criticism of Miss DOBBIN'S work is solely that the reasons assigned for her procedure are faulty and insufficient,—although, as a matter of fact, the best of reasons did actually exist, and I have every reason to believe that she has done a very creditable piece of work.

S. D. T.

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NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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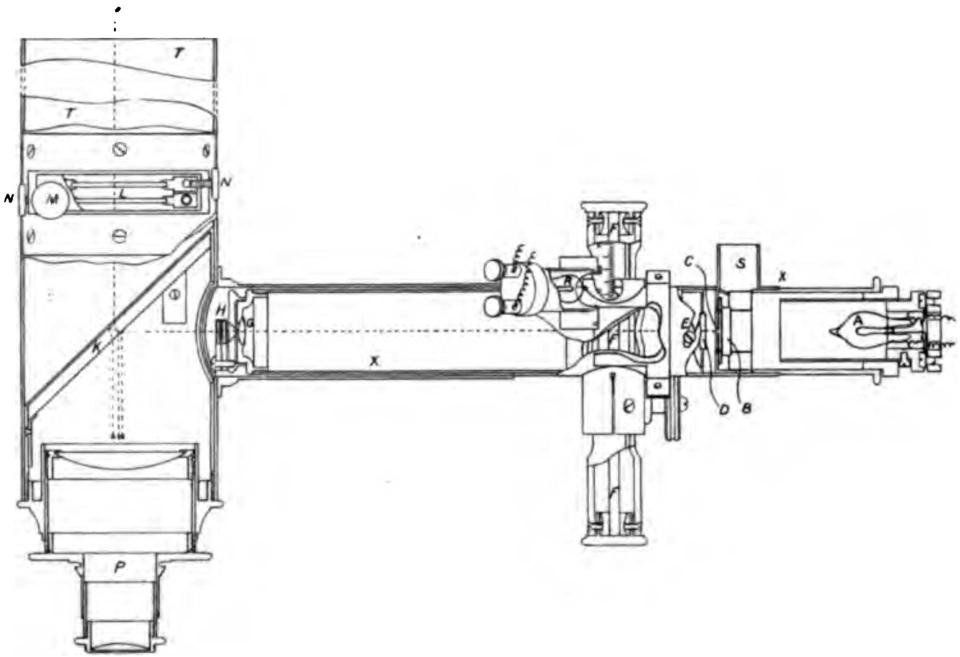

THE RUMFORD PHOTOMETER OF THE LICK OBSERVATORY.

PUBLICATIONS

OF THE

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VOL. XVII. SAN FRANCISCO, CALIFORNIA, AUGUST 10, 1905. No. 103.

INVESTIGATION OF THE RUMFORD PHOTOMETER OF THE LICK OBSERVATORY.

BY JAMES D. MADDRILL.

About five years ago, a photometer of new type, devised by Professor E. C. PICKERING, and constructed with the aid of the Rumford Fund of the American Academy, was received at the Lick Observatory. It was planned with special reference to convenience of use and reduction.

The telescope objective forms an image of a star in the focal plane of the ocular P (see illustration). An artificial star is formed beside this, by the system: lamp A, pin-hole diaphragm C, ground-glass D, projecting-lens G, and diagonal plane glass reflector K. The image reflected by the back surface of the diagonal plate is not used, except to aid the observer in bringing the images of different real stars successively to the same position relatively to the artificial star. The artificial star can be made to resemble the real star image in size by adjusting the distance of the ground-glass D from the diaphragm C, and also by moving the lamp A toward or away from the diaphragm. D is movable longitudinally by a lateral motion of the screw E in an inclined slot. The blue-glass B gives the artificial star the color of the "average" real star. The brightness of the artificial star can be varied at will by moving a "wedge" F of photographic film, which cuts off a part of the light by absorption and reflection, the variation in magnitude being nearly proportional to the displacement of the wedge. The wedge has a range of about four and a half magnitudes. If the artificial star is too bright for comparison with a real star, one or both of the shades H can be interposed in the cone of rays, and the light reduced about two or four magnitudes, respectively. If the artificial star is not bright enough, the brightness of the real star image can be diminished by using

one or both shades L, or, if necessary, by cutting down the aperture of the telescope.

To determine the magnitude of a star *x*, the artificial star is made equal to it in brightness and the position of the wedge is read from a graduated scale. The artificial star is then compared with a neighboring star of known magnitude and the wedge-scale reading taken. Progressive light changes in the artificial star are practically eliminated by immediate repetition of comparisons in the reverse order. The difference of magnitude between *x* and the standard star is obtained by converting the difference of scale-readings into magnitudes.

Preliminary measures of standard stars by Dr. AITKEN early showed that the change of absorption per scale-division was not the same at different parts of the wedge, and that an absorption-curve or table would be required to obtain results of the accuracy desired. The measures also showed that the determination of such a curve from stars would demand a very large number of settings. At the suggestion of Director CAMPBELL, the photometer was taken to Berkeley for measures on the Lummer-Brodhun laboratory photometer, kindly placed at our disposal by Professor SLATE. One side of the screen was illuminated by light passing through the wedge, and the other side by light from an illuminated surface whose distance could be changed and measured. The wedge absorption was determined at scale-divisions 0, 5, 10, . . . to the end at 65. The following values of the absorption relative to the absorption at scale-reading 0, resulted:—

Wedge.	Rel. Abs. in Mag.	Wedge.	Rel. Abs. in Mag.
0	0.000	35	2.556
5	0.045	40	3.002
10	0.414	45	3.370
15	0.968	50	3.577
20	1.421	55	3.612
25	1.772	60	2.54
30	2.108	65	0.02

The measures very closely resemble those made on this wedge by three observers at Harvard College Observatory before the photometers were sent out. But the curve differs considerably in slope (or average value of change of absorption per division) from the value found by Dr. AITKEN from

star measures. The phenomenon is probably due to the different effect on points and surfaces of the diffusion by the silver grains of the wedge. Varying the apparatus in the laboratory, it was found that the slope was affected, but that the form of the curve was not. That is, all the curves could be obtained from any one by a simple "stretching" of the curve in the direction representing change of absorption.

A number of measures of *Pleiades* stars were accordingly made by Dr. AITKEN to obtain data for the determination of the "stretching factor" to be applied to the curve of relative absorption tabulated on page 122. The measures gave $f = +0.261 \pm 0.011$. It was found that change of aperture or use of shades affected f, a somewhat larger value resulting when the aperture was cut down or when the shades L were used. The physiological effect of change of background seems to be different for stars of different brightness. The value $+0.261$ is a mean value adopted for apertures larger than six inches, with or without shades. Differences of magnitude, measured with any combination of apertures—over six inches—and shades, will not be more than one or two per cent in error if the reduction employs the curve obtained by increasing each tabulated value (p. 122) by 0.261 of itself. The result of this stretching is given in the following table, in which the thousandths have been dropped and the relative absorption, m, interpolated for each division, d:—

TABLE OF m WITH ARGUMENT d.

d	00	10	20	30	40	50
0	0.00	0.52	1.79	2.66	3.79	4.51
1	0.00	0.67	1.89	2.76	3.90	4.54
2	0.00	0.82	1.98	2.87	4.00	4.56
3	0.01	0.96	2.07	2.99	4.09	4.57
4	0.02	1.10	2.15	3.10	4.17	4.57
5	0.05	1.22	2.23	3.22	4.25	4.56
6	0.10	1.34	2.31	3.33	4.32	*
7	0.17	1.46	2.39	3.45	4.38	*
8	0.26	1.57	2.47	3.57	4.43	*
9	0.38	1.68	2.56	3.68	4.47	*
10	0.52	1.79	2.66	3.79	4.51	*

A careful examination of the absorption of the shade-glasses, made with the laboratory photometer, gave for the

shades L: I, $0^m.89$; I and II, $1^m.75$. It has never been found necessary here to use both shades H, the shade No. 2, nearest the projecting-lens, being sufficient to extinguish the artificial star at high readings of the wedge. The absorption of this shade is $1^m.72$.

The practical range of the photometer for direct comparisons is about 7½ mag., from about 9½ mag. to 17 mag., with the 36-inch refractor, and from about 6½ to 14 mag. with the 12-inch. By a recent modification of the telescoping adapting-tube AX (since the drawing here reproduced), by which the lamp A can be moved about an inch closer to the diaphragm C than before, the range of direct comparison can be shifted about 1½ mag. in the direction of increased brightness. If a brighter lamp A were practicable, so that both shades H would be required to extinguish the artificial star, the range would be further increased to include stars 1½ mag. brighter. The present available battery capacity is barely sufficient for the lamp we are now using.

The following example will illustrate the method of reduction I have been using. The stars *a, b, c*, etc., are stars in the vicinity of *R Draconis*. The measures were made with the 36-inch refractor by Dr. AITKEN, 1903, August 19th. *d* is the mean of two sets of four settings each on the stars *a, b, c, d, e;* of three sets of four settings each on the stars *q, r, s, t, u*. *m* is taken from the table. Columns nine and ten indicate the accuracy to be expected. The Roman numerals indicate the shades L used. In the fifth column a constant, *k*, is introduced to convert the differential measures to absolute magnitudes based on the system of provisional magnitudes *M*. The last two columns give the results of similar measures made by the same observer on two other nights.

								Mean Range. Setting = Mag.			
*	*d*	*m*	Shades.	Obs.	*M*	*k*	Obs. Mag.	*d*	*m*	Aug. 20th.	Aug. 21st.
a I II	10.60	0.61	1.75	*k* — 1.14 =	11.12	12.26	11.51	± 1.2	± 0.18	11.52	11.45
b I II	12.78	0.93	1.75	— 0.82	11.82	12.64	11.83	0.9	.12	11.76	11.87
c I II	14.51	1.16	1.75	— 0.59	12.20	12.79	12.06	1.2	.14	12.20	12.17
d I II	18.66	1.64	1.75	— 0.11	12.38	12.49	12.54	0.7	.08	12.29	12.31
e I II	16.16	1.36	1.75	— 0.39	12.67	13.06	12.26	0.6	.07	12.31	12.40
								Mean	.12		
q —	38.87	3.67	—	+ 3.67	....	....	16.32	1.6	.18	16.53	16.41
r —	40.37	3.83	—	+ 3.83	....	....	16.48	1.4	.15	16.71	16.45
s —	43.13	4.10	—	+ 4.10	....	....	16.75	1.7	.14	16.69	16.67
t —	44.14	4.18	—	+ 4.18	....	....	16.83	0.8	.06	16.77	16.68
u —	47.99	4.43	—	+ 4.43	...	....	17.08	2.2	.10	17.00	17.01
					Mean *k* =	12.65		Mean	.13		

A discussion of all the observations made by the author that are suitable for determination of probable error shows the probable error of a single determination, based on two sets of four settings each on a star, to be ± 0.050 mag.

MT. HAMILTON, July 31, 1905.

PLANETARY PHENOMENA FOR SEPTEMBER AND OCTOBER, 1905.

BY MALCOLM MCNEILL.

PHASES OF THE MOON, PACIFIC TIME.

First Quarter, Sept.	5,	8^h 9^m P.M.	First Quarter, Oct.	5,	4^h 54^m A.M.
Full Moon, "	13,	10 10 A.M.	Full Moon, "	13,	3 3 A.M.
Last Quarter, "	21,	2 13 P.M.	Last Quarter, "	21,	4 51 A.M.
New Moon, "	28,	1 59 P.M.	New Moon, "	27,	10 58 P.M.

The Sun reaches the autumnal equinox and crosses the equator from north to south at about 9 A. M. September 23d, Pacific time.

Mercury passed inferior conjunction with the Sun August 29th and became a morning star. At the beginning of September it is still too close to the Sun to be seen, but it moves rapidly away and reaches greatest west elongation September 15th. Its apparent distance from the Sun is then 17° 54′. This is considerably less than the average, because the planet is then near its perihelion, which it passes a little more than two days later. However, the planet is near a part of the ecliptic which is several degrees north of the Sun's position, and is in the part of its orbit which is north of the ecliptic. The two causes to a large extent compensate for the small elongation, and the planet can be seen in the morning twilight for a fortnight or more about the time of greatest elongation. At that time it rises fully an hour and a half before sunrise, and the interval is more than an hour for a week or so before and after September 15th, the date of greatest elongation.

Venus is a morning star, rising more than three hours before sunrise on September 1st. The interval shortens to less than three hours by October 1st, and at the end of the month it is only a little more than two hours. Since the planet

passed its greatest west elongation in July its apparent distance from the Sun has diminished from 46° to 38°, and this distance suffers a farther diminution to 23° by the end of October. During the two months the planet moves among the stars from *Cancer,* through *Leo* and into *Virgo,* 70° eastward and 23° southward. On the night of September 25-26th *Venus* passes not quite the Moon's apparent diameter south of the first-magnitude star *Regulus, α Leonis;* and somewhat later on the same night the Moon passes less than 1° south of the planet. The Moon also occults the star earlier in the night, the occultation being visible from a large part of the United States. The real distance of the planet from the Earth is increasing quite rapidly, being nearly five times as great on October 1st as it was on April 27th, the time of conjunction, and there has been a considerable diminution of brightness, but *Venus* is still the most brilliant object in the early morning sky.

Mars, although it has lost much of the brightness it had at the time of opposition, is still a noticeable object in the southwestern sky in the evening. It sets shortly after 10 P. M. on September 1st, and shortly after 9 P. M. on October 31st. It moves from *Scorpio* to the eastern part of *Sagittarius* about 45° eastward during September and October. In early September it is quite near the first-magnitude red star *Antares, α Scorpii.* The time of nearest approach is September 4th: on this date the planet is less than 3° north of the star. During the two months its distance from us in millions of miles increases from 96 to 128, and there is a consequent diminution of brightness of nearly fifty per cent.

Jupiter now rises so that it may be observed as an evening object, at about 10:30 P. M. on September 1st, about 8:30 on October 1st, and before 6:30 on November 1st. It is in the constellation *Taurus,* about 5° north and west of the first-magnitude star *Aldebaran,* and up to September 25th it moves about 1° eastward; then it begins to move westward, and by the end of October it has moved about 2°, retracing almost exactly its eastward path, occupying a position only 6′ from that which it held on August 20th.

Saturn passed opposition on August 23d, and is therefore above the horizon nearly the entire night early in September. It sets about four minutes earlier each night, and by the end

of October it sets half an hour after midnight. It is on the border of *Aquarius* and *Capricorn,* and moves slowly westward about 2° 30′ until October 31st, when it becomes stationary. As there are no bright stars in that part of the sky, the planet can be easily identified, although it is not much brighter than a first-magnitude star.

Uranus is in the southwestern sky in the evening. It sets at about midnight on September 1st and at about 8 P. M. on October 31st. It is in *Sagittarius,* and moves slowly westward until September 9th. Then it begins to move eastward, making a little more than 1° by October 31st. The nearest bright star is the star in the end of the handle of the "milk dipper," and *Uranus* lies beyond that at about the same distance as the nearest star of the bowl, but in the opposite direction.

Neptune is in *Gemini.* It rises about 1 A. M. on September 1st, and a little before 9 P. M. on October 31st.

NOTES FROM PACIFIC COAST OBSERVATORIES.

Photographic Measures.

Of importance and interest to those engaged in the work of measurement or reduction of photographic plates is a dissertation by Walter Zurhellen, of Bonn University, entitled "Darlegung und Kritik zur Reduction photographischer Himmelsaufnahmen."

The photographic method of investigation has been given a new impetus recently through its application in the determination of the solar parallax and by the completion and distribution of a few volumes of the astrographic catalogue.

The great enthusiasm which appeared when the possibilities of the photographic method began to be realized was dampened by the fact that an excessive amount of time and labor was found to be required not only to prepare for work by adjusting and investigating the errors of the photographic telescope and the measuring apparatus, but to get the photographs, measure the plates, and perform the reductions, after all this preliminary work had been done. The recent tendency has been to reduce the labor involved by the development of special methods suited to the various problems and the construction of tables to facilitate the reduction.

Dr. Zurhellen has given an exposition of the methods in most general use in the reduction of photographic measures. The first section is an introduction in which the coordinate systems most used in the subsequent pages are clearly defined with the help of figures, and algebraic relations are given between the coordinates. The second section is devoted to the formulas used in computing corrections for refraction, aberration, precession, and nutation, and in determining the plate constants with the help of known stars on the plate. The discussion of the refraction formulas is somewhat unsatisfactory, due to the involved nature of the algebraic processes and the difficulty of estimating the relative importance of the terms

which are dropped early in the discussion. The objections urged against the very simple and elegant formulas produced by Professor TURNER (*Monthly Notices*, Vol. LVII, p. 136) do not seem to the writer to be valid. TURNER'S formulas, as given, yield the components of the displacement due to refraction as a function of the true coordinates of the star, the y axis of reference passing through the pole. If the coordinates of the stars and of the center of the plate as affected by refraction be substituted for the corresponding true coordinates and the constant of refraction appropriately modified, the formulas will yield the components of the corrections necessary to remove the effect of refraction from the measured coordinates. Tables to facilitate the application of these formulas have been constructed at this observatory and are to be published in Volume VII of the *Publications of the Lick Observatory*.

The remainder of this section contains a valuable discussion of the other corrections which must be applied in the derivation of ideal coordinates. The discussion of the corrections necessitated by the inclination of the plate to its true position perpendicular to the optic axis will prove especially valuable to those working with lenses covering a field several degrees in diameter. The treatment of Professor TURNER'S six constant method of reduction seems rather severe, particularly the last sentence of the section, which states that the method should be "altogether discarded." The general opinion seems to be that in many cases Professor TURNER'S method is sufficiently accurate and more convenient than any other.

The last section deals with the transformation of ideal coordinates into intervals of Right Ascension and Declination. The matter is handled clearly and concisely and the advantages of the several methods well stated.

The list of books and articles consulted in preparing the dissertation contains the important contributions to the subject.

This dissertation, though it does not claim to contain many new formulas, is a real contribution to the subject, as an intelligent collection and discussion of the most important method now in use. The main obstacle to the more general use of the photographic method is, as stated above, the excessive labor of the measurement and reduction—particularly the latter. The author has recognized that the first step in overcoming this

obstacle is to collect the various methods for a comparative study. B. L. NEWKIRK.

The Students' Observatory has been honored recently by the visits of several men of distinction in the scientific world. Dr. JOHN M. VAN VLECK, Professor of Mathematics and Astronomy in Wesleyan University, of Middletown, Connecticut, spent some days in Berkeley in the latter part of May. Some weeks later we were visited by Dr. OTTO TETENS, who has been engaged for several years in making magnetic observations in Samoa under the auspices of the Royal Academy of Sciences of Göttingen. More recently, the observatory has been favored by visits from Professor E. O. LOVETT, of Princeton University, Mr. DOUGLASS, formerly of the Lowell Observatory, Flagstaff, Arizona, and Professor ROBERT SIMPSON WOODWARD, President of the Carnegie Institution, of Washington. A. O. LEUSCHNER.

OBSERVATIONS OF THE SIXTH SATELLITE OF *JUPITER*.

The sixth satellite of *Jupiter* shows on several plates recently taken with the Crossley reflector. Comparatively rough measures of the plates on the nights of July 25th, 26th, and 27th, with exposures of 30 minutes, 1 hour, and 1½ hours, respectively, gave the following positions for the satellite relative to *Jupiter*, a reversed image of which appears on the plates:—

Date.	Distance.	Position Angle.
July 25.95	25′.1	55°.0
26.97	24 .3	52 .7
27.93	23 .6	50 .7

The parts of the star-trails used in the measures were estimated to correspond to the times given above, and may be in error by about 0.01 of a day. Definitive measures should not change the distances very much, but may change the position-angles by one or two tenths of a degree. These observations show the satellite to be about ten days behind the ephemeris positions which were computed for it by Dr. FRANK E. ROSS (*L. O. Bulletin* 78).

The satellite is of about the fourteenth photographic magnitude. S. ALBRECHT.

July 29, 1905.

NEW COMPANIONS TO KNOWN DOUBLE STARS.

In Number 102 of these *Publications* I announced the discovery of new companions to three well-known Struve double stars. Since then I have found that the pairs Σ 112, Σ 1952, and Σ 2414 have companions not seen by STRUVE, nor, so far as I am aware, by any other observer. The means of my measures of these pairs are:—

Σ 112.

1905.578	186°.0	4″.42	9.0–13.5	1^n	B and C. New
1905.578	330 .7	21 .83	8.7– 9.0	1	A and B = Σ 112

Σ 1952.

1905.47	22°.5	0″.51	8.5–10.2	3^n	A and B. New
1905.45	222 .0	16 .18	8.5– 9.2	2	AB and C = Σ 1952

Σ 2414.

1905.51	95°.9	0″.73	8.0–13.5	3^n	A and B. New
1905.44	278 .5	17 .15	8.0–11.0	1	A and C = Σ 2414

I have also found the principal component of the wide pair *h* 804 to be a close double star. My measures are:—

1905.56	314°.6	0″.31	9.0– 9.8	2^n	A and B. New
1905.55	228 .7	19 .45	8.8–11.0	1	AB and C = *h* 804

July 31, 1905. R. G. AITKEN.

CORRIGENDA.

In Number 102 of these *Publications*, page 105, after line 16, insert:—

The first attempt to remove these residuals by linear differential relations so as to produce a parabola resulted in:—

$\Delta\alpha \cos\delta$	$-02''.2$	$\pm 00''.0$
$\Delta\delta$	$+47.6$	$+17.8$

In the same number, page 111, title and line 2, for *ζ Scorpii* read ***ξ Scorpii.***

GENERAL NOTES.

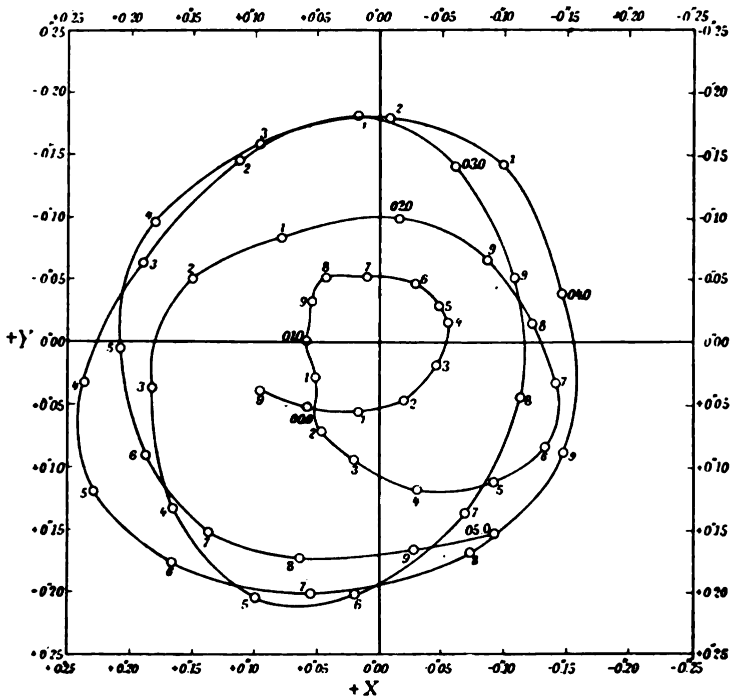
Variation of Latitude.—From the annual report of the work accomplished by the Central Bureau of the International Geodetic Association it appears that the number of latitude determinations made at the various stations established for the purpose of determining the variation of latitude gives a total for 1904 of 11,909, distributed as indicated in the first column of the tabulation given below. The total number of observations made from the time the stations were established, fall of 1899 to the beginning of 1905, is 63,634, distributed as indicated in the second column of the table.

	1904.	Total.
At Mizusawa	1,781	8,464
Tschardjui	1,831	9,285
Carloforte	3,173	16,998
Gaithersburg	1,361	9,378
Cincinnati	1,329	8,038
Ukiah	2,434	11,471

Provisional results for the latitude work of 1904 have been published by Professor ALBRECHT in the *Astronomische Nachrichten* No. 4017. The amplitude of the polar motion was not quite so large as in the preceding year. The motion of the Earth's north pole, from 1899.9 to 1905.0, is represented in the accompanying figure (see opposite page) taken from the number of the *Nachrichten* mentioned above.

No change in the observing programme of the latitude stations has been made since they were established. Ninety-six pairs of stars were selected for observation, and these were divided into twelve groups. For six of the pairs of each group the stars have small zenith-distances, mostly less than 15°. The other two pairs of each group were selected from stars of large zenith-distances, about 60°. These latter, the so-called refraction pairs, were introduced with the idea of detecting, if possible, any abnormal conditions in the refraction, and the latitudes given by them have never been included in the final results. The latitudes determined from the refraction pairs are considerably less accurate than those determined from the zenith pairs, and this is due mainly to four causes: First, at a zenith-distance of 60° the star-images are always, except

under the very best conditions, much more diffuse and unsteady than at small zenith-distances; second, when the telescope is pointed to a large zenith-distance the latitude levels are more likely to be disturbed than at small zenith-distances; third, in observing the stars of the refraction pairs it is necessary for the observer to stand in a rather awkward and unsteady position, and it is not possible to make the most accurate micrometer-settings under these circumstances; fourth, the south star of a refraction pair moves so rapidly that it is impossible for the



observer to make the micrometer-settings with a sufficient degree of deliberation, and the north star of the pair moves so slowly that the heat from the observer's body, which is adjacent to the south ends of the latitude levels, may have a disturbing effect upon them.

Beginning with the first of the year 1906 a change in the observing programme is to be made, and all of the refraction pairs are to be dropped and other zenith pairs substituted. Six of the present zenith pairs are to be replaced with new ones,

and the new pairs are to be selected in such a way that in each group the positive and negative differences of zenith-distances shall very nearly equal zero for the epoch 1908.0, it being the intention to observe on this revised programme until 1910.

The work of the latitude-stations is to be carried on for an indefinite length of time, and two additional stations are now being established in the southern hemisphere. The one in connection with the National Observatory of the Argentine Republic at Cordoba and the other in connection with the observatory at Perth, West Australia. The two stations are on the same parallel, about 32° south, and 180° apart in longitude. It is not possible, from observations in the northern hemisphere alone, to reach sure ground from which to interpret all of the phenomena presented in the variation of latitude.

From No. 4, Band I, *Mitteilungen der Nikolai-Hauptsternwarte zu Pulkowo,* it is learned that a new zenith-telescope, similar to those in use at the International Latitude observatories, has been provided for the Poulkova Observatory. The instrument is somewhat larger than those in use at the International Latitude observatories, and differs from them in some important details, which I hope to discuss at some future time. This instrument is being used in systematic observations for the variation of latitude, and a comprehensive programme has been laid out. On account of the shortness of the summer nights at Poulkova and the long spells of cloudy weather in the winter it has been found necessary to depart considerably from the programme of the International Latitude observatories. Seventy-four pairs divided into nine groups are used instead of ninety-six pairs divided into twelve groups. No stars of a zenith-distance of more than 21° are used. It is noticed from the diagram showing the observing programme, that in summer for a few dates the observations begin before sunset. I do not hesitate to state, judging from my experience in this work, that I believe this to be a mistake. One of the chief sources of error in latitude work by the Talcott method comes from the "bad behavior" of the levels. and this almost always takes place in the early evening hours when the temperature is falling rapidly. At Ukiah it has been noticed that the levels almost invariably behave better during the second half of the night's work than during the first, although in our

programme the shortest interval between sunset and the beginning of observations is one and one half hours. I believe the accuracy of the work could be increased by shoving the whole programme along further into the night. I hope to take up soon an examination of the results thus far published to see if there is any difference between the degrees of accuracy of the results of the first and second halves of a night's work.

In No. 754 of the *Astronomical Journal,* Dr. SCHLESINGER has an article entitled "On Systematic Errors in Determining Variations of Latitude." He says, by way of introduction: "Observations for determining the variation of latitude, however carefully they may be made, seem to be subject to considerable systematic discordances. It is doubtful whether these have their origin in external causes (such as meteorological), or whether their explanation is to be sought in the instrument or in the observer.

"It is obvious that the question can be decided by setting up two instruments side by side, and having two observers make simultaneous observations with them. It will occasionally happen with each instrument that a night's observations will deviate largely from those of the preceding and succeeding nights. If these deviations follow the same course for both instruments, we must conclude that they arise from some external cause, probably beyond the control of the observer.

"The conditions for such a test happen to be well fulfilled by certain observations made before the present subject was in mind. I refer to the two independent series by MARCUSE and PRESTON, at Waikiki, near Honolulu, in the Hawaiian Islands, in 1891 and 1892. The former of these observers represented the International Geodetic Association, the latter the United States Coast and Geodetic Survey. In that day the reality of latitude-variations was still doubted by some, and Hawaii was selected as a site for an observing-station because the latitude-variations at that place should be (and in fact proved to be) the reverse of those at European stations, the difference in longitude being about 180°. Two observers were sent, because 'previous experience has shown that a single series may easily suffer interruption because of the illness of the observer, or the failure of the instrument.' Waikiki is on the south side of the island of Oahu, about two

miles southeast of Honolulu. PRESTON'S station was within four hundred feet of the shore, and MARCUSE'S was thirty-one feet north and eighteen feet west of PRESTON'S."

Dr. SCHLESINGER then goes on to reduce the two series to a common basis, and finds as a final result that both of the series are affected by a common systematic error. The investigation does not reveal the cause of these errors, but Dr. SCHLESINGER hopes, in a later paper, to throw some light upon the subject. S. D. T.

The following notes have been taken from recent numbers of *Science*:—

Yale University has conferred its doctorate of science on Professor GEORGE E. HALE, director of the Solar Observatory of the Carnegie Institution.

Information from Ottawa states that the Dominion Observatory has been practically completed. The telescope has been mounted, Astronomer W. F. KING, with his staff, has taken possession of the building, and observation work has begun. The telescope is a refracting instrument 19 feet 6 inches long, with a 15-inch lens. In addition to this telescope, the observatory has a transit, spectroscopic instruments, and the equipment of a first-class institution. The building cost $92,000 and the telescope $14,000.

An astronomical observatory, to be known as the Cecil Duncombe Observatory, is to be established in connection with the University of Leeds. A building with an aluminium dome is being built at one of the highest points of the city, and in it will be placed the telescope recently presented to the university by Captain C. W. E. DUNCOMBE, together with the transit instrument presented by the late Mr. W. E. CROSSLEY.

Princeton University has conferred the degree of Doctor of Laws on Professor CHARLES AUGUSTUS YOUNG, who has this year become professor emeritus of astronomy, after holding the chair at Princeton since 1877.

Columbia University has conferred the degree of Doctor of Science on Dr. R. S. WOODWARD, who has resigned the chair of Mechanics and Mathematical Physics to accept the presidency of the Carnegie Institution.

Oxford University has conferred its Doctorate of Science on GEORGE H. DARWIN, F. R. S., professor of astronomy at Cambridge.

The following extracts have been taken from an account in the *London Times* of the report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich:—

Preparations for the approaching eclipse of the Sun were much in evidence. The Astronomer Royal, accompanied by Mr. F. W. DYSON and Mr. C. DAVIDSON, hopes to observe it from Sfax, in Tunis; Mr. E. W. MAUNDER will go to Labrador on the invitation of the Canadian Government, and two other members of the staff hope to go to Palma, in Majorca. The Sfax party propose to carry out the same programme as in 1900 and 1901, except that the 13-inch astrographic equatorial will be used in addition to the Thompson 9-inch coronagraph to obtain large scale photographs of the corona; its spectrum will be photographed with two spectroscopes lent by Major HILLS. Mr. MAUNDER is taking the Dallmeyer 4-inch coronagraph and a 4-inch rapid rectilinear lens, these instruments being mounted equatorially, as a cœlostat—that most convenient adjunct to an eclipse expedition—is unfortunately not available. An attempt is to be made to take some photographs under exactly similar conditions in Labrador and Egypt (the two extremities of the eclipse track), and afterwards combine them in a stereoscope, with a view of determining the structure of the corona in three dimensions, and examining whether any signs of rotation are shown. Since two and one-half hours elapse, it is quite possible that some rotational shift may be visible.

The proper motions of the stars in GROOMBRIDGE's catalogue have been recently redetermined and classified according to their type of spectrum, a very interesting point standing out clearly from the discussion,—namely, that stars whose spectrum resembles that of our Sun have large proper motions, and, therefore, are presumably nearer to us than the stars whose spectrum resembles that of *Sirius*. It would seem, therefore, that our Sun is one of a cluster of "solar" stars, while the Sirian stars lie in the background, and are apparently associated with the Milky Way.

The "variation of latitude" is now looked upon as an accepted fact, and is applied as a correction to all the meridian observations; it is still, however, considered safer not to use the predicted value, but to wait till the end of the year, and then apply the values deduced by Professor ALBRECHT from the results of all the co-operating observatories. It is found that the application of this correction makes the solar observations in different years more harmonious with one another, and also explains the anomalies in the observations made with the reflex zenith-tube. Since the vindication of the character of this instrument, observations with it have been vigorously pushed forward, more than a thousand observations of sixty-one different stars having been made during the year. It is hoped that, after a few years, this material will supply new values of the constants of aberration and nutation.

The 30-inch reflector presented by Dr. COMMON has been used for the photography of fifty-nine minor planets and four comets. In particular Comet *a* 1904 may be mentioned, as it remained visible for a full year, and was observed on sixty-two nights. This comet was notable for its large perihelion distance, which was 2.7 times the Earth's distance from the Sun. It remained visible till it was quite near the orbit of *Jupiter*. ENCKE'S comet was photographed on one night, and photographs have also been obtained of two other faint comets that were discovered last winter. These cometary photographs are found to give more accurate positions than the visual observations that were formerly obtained, and in consequence the latter have been discontinued.

Great progress has been made with the measurement and reduction of the numerous photographs of the small planet *Eros* with a view of obtaining an improved value of the Sun's distance. The photographs have all been measured, and positions of the reference-stars adopted, and it is expected that the work will be concluded in a few months. The work for the Astrographic Catalogue is now practically completed. The stars have all been measured, but the zone from 77° north declination to the North Pole is not yet printed. The catalogue will contain 178,750 stars, which implies nearly 4,000,000 in the entire heavens, of which the Greenwich zone covers one twentieth. It is proposed in a future volume of the Astrographic Catalogue

to give the star-places in the form of Right Ascension and Declination in addition to the "rectangular coordinates" hitherto printed. This has not yet been finally decided. The photographic enlargement of the chart-plates is steadily proceeding. Over two hundred plates have been copied and distributed to about fifty observatories and representative institutions.

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NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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STATIONARY METEOR-RADIANTS.

By B. L. NEWKIRK.

Meteoric phenomena offer a field for investigation rich in the possibility of important contributions to the solution of the problem of cosmogony. The orbits of meteors seem, like those of comets, to be in the main very eccentric. No theory of the evolution of a world system can be complete without accounting for these eccentric orbits as well as the more or less approximately circular orbits of the great planets and asteroids. The object of this note is to point out one of the most striking of meteoric phenomena and to call the attention of our non-professional astronomers to the importance of this field of investigation, which is easily accessible to them. Observations of the flight of meteors have hitherto generally been made with no more apparatus than a short wand and a sphere of wood, upon which the star constellations have been mapped. More accurate observations of the direction of flight and the velocity of the meteor require two cameras of short focus and wide angle with especially arranged shutters.

Mr. W. F. DENNING, of Bristol, England, began to observe the flights of meteors at the time of the *Leonid* shower in 1866. Since that time, he has observed many thousands of meteor flights and our knowledge of the observed phenomena of meteoric display has been greatly increased by his contributions. Mr. DENNING'S method of observation is exceedingly simple. He takes up a position on a moonless night in his garden with a short wand in his hand and a sphere upon which the constellations visible on that evening are plotted. When a meteor appears, he raises the wand as quickly as possible and holds it so that its projection on the sky shall coincide as nearly as possible with the path of the meteor.

This enables him to note quite accurately the location of the path of the meteor with reference to the neighboring stars. This path is then plotted on the sphere and the time noted. On a good night, Mr. DENNING observes on the average about eleven such trails per hour. Upon comparing these trails, it is observed that several of them would intersect in the same point if they were extended in the arc of a great circle some distance back of the point where the meteor became luminous, and therefore visible. These several paths would all seem to diverge from the same point. This indicates that these meteors were traveling in parallel paths at the time of their collision with the Earth. An analogous phenomenon is observed when seemingly divergent bars of sunlight are seen piercing a cloud. The point on the celestial sphere from which several meteor paths seem to diverge is called a "meteor-radiant." Its right ascension and declination are noted and entered in a catalogue of meteor-radiants, of which Mr. DENNING has published two, one in the *Monthly Notices* and the other in the *Memoirs of the Royal Astronomical Society of Great Britain.*

It is to be noted that the position of the radiant point depends solely upon the *direction* of the motion of the meteor *relative to the Earth.* This relative motion of the meteor is the resultant of the composition of the velocity of the Earth with that of the meteor. If either of these components changes its direction, the direction of the resultant changes. Now, suppose there were a great swarm of meteoric particles moving in parallel lines through the solar system so as to cross the Earth's orbit at all points, then we should encounter some of the meteors of this swarm every night in the year. If these meteors were observed at different intervals throughout the year and their radiant points determined, we should of course find the radiant point shifting from night to night, the shift being due to the changing direction of the Earth's motion as it describes its orbit. An example of this phenomenon is found in the *Perseid* family. Meteors of this family are seen as early as the 19th of July and as late as the 25th of August, and the shifting of the radiant amounts to about forty degrees. Mr. DENNING'S ability to observe distinguishing characteristics so as to be able to classify meteors according

to families has been questioned, but his claim that long experience and careful observation have enabled him to distinguish differences of color, velocity of flight, length of path, or peculiarities in the illumination, which escape inexperienced observers and by means of which he identifies a meteor as belonging to any particular family, must be admitted.

The announcement of his discovery of *stationary radiant* points created a good deal of wonder and not a little discussion among those interested in meteoric phenomena from the theoretical point of view. Mr. DENNING asserts that there are certain radiant points stationary in the sky from which meteors presenting common "family" characteristics appear to diverge throughout intervals of weeks and even months. The incredulity of theoretical astronomers can be realized when one tries to picture to himself the complicated system of orbits in which the various meteoric particles of such a family of meteors would have to move. As the Earth moves about in its orbit, changing the direction of its motion by about one degree a day, the direction and magnitude of the velocity of the meteoric particles would have to vary so that the resultant would have a constant direction. Computation of orbits of meteoric particles coming from the same radiant at different dates have been made.[1] Some of the orbits were found to be direct and some retrograde, and the greatest diversity appeared in the case of the other elements, as might have been expected.

Mr. DENNING'S catalogue records the positions of a large number of stationary radiants. Among the most important are (*Monthly Notices,* Vol. 45, p. 101):—

	α	δ	Apparent Duration.	Shower.
I	30°.0	36°.0	July 16–Nov. 14	β *Triangulids*
II	46 .0	45 .6	July 6–Nov. 30	α-β *Perseids*
III	61 .0	47 .7	July 25–Nov. 27	μ *Perseids*
IV	61 .8	36 .8	Aug. 2–Dec. 31	ϵ *Perseids*
V	76 .2	32 .6	July 23–Dec. 27	ι *Aurigids*
VI	80 .2	22 .9	Aug. 24–Jan. 15	ζ *Taurids*

Mr. DENNING speaks as follows concerning the phenomenon (*Monthly Notices,* Vol. 45, p. 111): "The first decided intimation of their presence is usually recognized when the

[1] BREDIKHINE: *Bul. de l'Acad. de St. Petersbourg,* V Serie, T. 12, p. 95, T. 13. p. 189.
TISSERAND: *Comptes Rendus,* T. 109, p. 345.

radiants are near the Earth's apex. At such times they furnish very swift streak-leaving meteors. Later on, they lose the capacity to generate streaks, and ultimately are transferred into the slow train-bearing meteors whose radiants cluster in regions far removed from the Earth's direction of motion. Yet during the whole time of the display, and while the individual meteors are thus visibly affected by the change, progressing from night to night, in the position of their divergent points relatively to the Earth's apex, their radiants remain immovable; and the fact is conclusively proved, not by approximate accordances, but by absolute coincidence in these points as observed with great care and precision."

Two ingenious and suggestive explanations of the phenomenon of stationary radiation appeared in the *Monthly Notices of the Royal Astronomical Society,* Vol. 59, p. 140 and p. 179. Professor TURNER, of Oxford, endeavored to explain the growth of such a family of orbits by the perturbation of the Earth upon a family of meteoric particles moving at first in nearly identical orbits which intersect the Earth's orbit at some particular point. There are serious objections to this theory. One very general consideration that militates against *any* theory based upon the perturbative effect of the Earth upon a single family of meteors is appended in a supplementary note.

The other explanation which appeared in the article above referred to in the *Monthly Notices* is by Professor A. S. HERSCHEL. He calls attention to the fact that if a resultant velocity is produced by the composition of one very large and one comparatively small velocity, a change in the direction of the small velocity does not materially change the direction of the resultant. If the velocity of the meteors were several hundred miles per second, the phenomenon of stationary radiation could be accounted for on the assumption of a broad stream of meteors crossing the Sun's system in parallel straight lines. The changing direction of the Earth's velocity would alter the direction of the resultant so slightly that the radiant would be stationary within the error of observation. The velocity of meteors as they fall upon the Earth is not, however, anywhere near so great as three or four hundred miles per second. So far as observations go, the evidence seems to

point to an orbital velocity of the meteoric particles not very different from the parabolic velocity. Now comes the ingenious part of Mr. HERSCHEL'S theory. He supposes that at some time in the past history of the solar nebula, before the material forming the Earth had liquefied, the solar system encountered a storm of meteoric particles moving in parallel lines at a velocity of several hundred miles per second. These particles pierced the nebulous material that was moving in the orbit in which the Earth now travels and passed through it, suffering a greater or less retardation. This meteoric storm might have endured for months or for years, and the radiant points of all the meteors would have been nearly the same because of the high velocity of the oncoming meteor particles. We may say the particles would have a common radiant within the error of observation. Now, it is to be observed that the retardations of any meteoric particle by the nebulous mass is tangential, so that *the radiant point remains unchanged as the particle passes through.* Its velocity relative to the nebulous ball as it leaves is identical in *direction* with its relative velocity as it approaches, the magnitude only having been changed by the retardation. Now, such of these particles as escape from the nebulous ball with a velocity less than the parabolic velocity will return again at some future time (perturbations neglected) to the same point and with the same velocity. Such of these particles as encounter the Earth again at some future date will have a common radiant,—namely, the radiant of the original meteoric storm.

The suggestiveness of this theory is remarkable. It offers an explanation for the origin of comets as masses of matter that have in ages past collided with the solar nebula and lost so much of their velocity that they were unable to escape from the Sun's system. The remarkable gap in continuity between the nearly circular orbits of the great planets and the very eccentric and long-period orbits of the comets and meteors is accounted for; the lack of many short-period, highly eccentric orbits being due to the great probability of collision or disintegration at the frequent perihelion passages. Such a meteoric storm, occurring at a critical stage in the development of a planet might have produced a disruption resulting in the formation of the asteroid ring.

The importance of research to confirm or disprove Mr. DENNING'S claim of the existence of stationary radiation, and the ease with which observations may be made, ought to recommend it to any one interested in the progress of astronomy. The vital connection which Mr. HERSCHEL'S explanation of stationary radiation gives the question of its actuality with the problem of the development of a world system lends such investigations a dignity which is in no wise impaired by the simplicity and seeming crudeness of the means employed. The clear sky, uniform good weather during the summer-time, and transparency of the atmosphere render many points in the interior of California peculiarly adapted for investigations of this sort.

NOTE.—In the above note on "Stationary Meteor-Radiants" I have alluded to a general objection to any theory which offers to explain the rise of a system of orbits to which stationary radiation might be due through perturbation, by the Earth, of meteoric particles originally moving in the same elliptic orbit. I shall show by an application of TISSERAND'S[1] criterion for the identity of two orbits that one of the orbits of such a family could not be produced from another by the perturbation of the Earth alone.

If any orbit has been produced from another by the perturbation of the Earth, the following relation must exist between the elements of the two orbits:—

$$(1)\ \frac{1}{a} + 2\sqrt{a\,(1 - e^2)}\cos i = \frac{1}{a'} + 2\sqrt{a'\,(1 - e'^2)}\cos i'$$

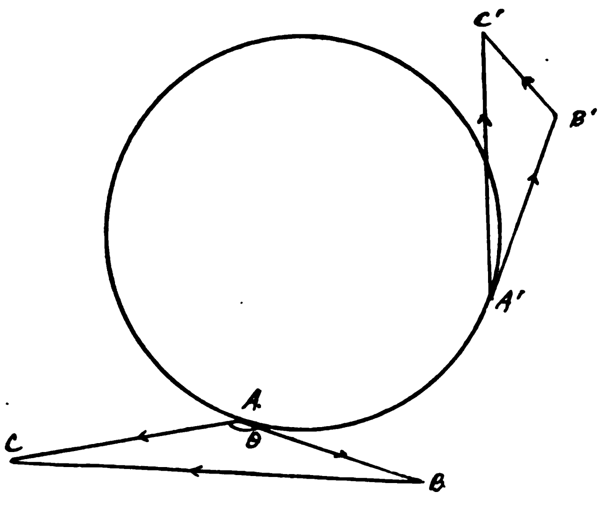
i and i' being the inclinations of the plane of the orbit of the disturbed body to the orbital plane of the disturbing body.

Mr. DENNING does not make accurate observations of the velocity, and it is therefore impossible actually to compute the various orbits belonging to a stationary radiant. The following statements previously quoted will however furnish sufficient data for the present purpose. He says (*Monthly Notices*, Vol. 45, p. 111): "The first decided intimation of their presence is usually recognized when the radiants are near the Earth's apex. At such times, they furnish very swift

[1] TISSERAND: *Mech. Cel.*, Vol. IV, p. 204.

streak-leaving meteors." In his catalogue of 1890 (*Monthly Notices,* Vol. 50, pp. 418 ff.) he uses the following adjectives to characterize meteors as regards velocity: "very slow," "slow," "rather slow," "swift," "rather swift," "very swift."

The following considerations lead to the conclusion that the orbit of the meteoric particle which meets the Earth when the radiant is near the apex is retrograde. Mr. DENNING'S notion of "very swift" is obtained by comparison with other meteors. It is definitely known that the *Leonid* meteors, for example, are traveling with an orbital velocity appropriate to an orbit of thirty-three years period. They meet the Earth when the radiant point is near the apex, and the velocity relative to the Earth must therefore be more than twice the orbital velocity of the Earth. (Let us leave out of account the acceleration due to the Earth's attraction.) It is safe to say that a meteoric velocity would not be described as "very swift" by Mr. DENNING unless its velocity relative to the Earth, exclusive of that due to the Earth's attraction, were at least twice the orbital velocity of the Earth. Mr. DENNING'S catalogue also shows that many of the stationary radiants en-



dure for more than three months. In the figure let the circle represent the Earth's orbit, the vectors AB and AC represent the velocity of the Earth and meteoric particle respectively.

The vector BC represents the motion of the particle relative to the Earth. The vectors AC and BC are not necessarily in the plane of the paper. The angle ABC is the angular distance of the radiant point from the apex of the Earth's way. This is less than 90°, if the longitude of the radiant point is equal to that of the apex.

$$\overline{BC}^2 = \overline{AB}^2 + \overline{AC}^2 - 2\overline{AB}.\overline{AC}\cos\theta$$

If $BC = 2AB$

$$3\overline{AB}^2 = \overline{AC}^2 - 2\overline{AB}.\overline{AC}\cos\theta$$

Either $\overline{AC} \gtreqless \sqrt{3}\,\overline{AB}$

or, $\cos\theta < O$.

But $\sqrt{3}\,\overline{AB} >$ parabolic velocity $= \sqrt{2}\,\overline{AB}$

Such a velocity could not have been produced by a previous perturbation of an elliptic orbit, for a particle leaving on a hyperbolic orbit would not return. The other alternative remains, and the orbit is retrograde, the angle θ being greater than 90°. The orbits of these particles which meet the Earth when the longitude of the apex is equal to the longitude of the radiant are, then, retrograde.

When the longitude of the apex is 90° greater than the longitude of the radiant the angular distance between the apex and the radiant (= A'B'C') > 90°. The orbit is necessarily direct (since B'A'C' < 90°) and the projection of A'C' upon A'B' is therefore greater than A'B'.

The elements a and r of a meteor's orbit are expressed as follows (TISSERAND's *Mech. Cel.*, Vol. I, p. 101 and p. 97):—

$$\sqrt{a(1 - e^2)} = \sqrt{p} = \frac{r^2\,dw}{k} = \frac{r\,V\sin\sigma}{V_e}$$

$$\frac{1}{a} = \frac{2}{r} - \frac{V^2}{k^2} = 2 - \frac{V^2}{V_e^2}$$

Here r represents the radius vector of the Earth, taken equal to unity, V the velocity of the meteor, V_e the velocity of the Earth, and σ the angle between the radius vector and the tangent to the meteor's orbit; k is the Gaussian constant, equal

to the velocity of the Earth, in the units here employed. Substituting these values in equation (1), placing

$$D = \sin\sigma \cos i$$
$$D' = \sin\sigma' \cos i'$$

and solving for V, we have

$$V = V_e D \pm \sqrt{V_e^2 D^2 + V'^2 - 2V_e V'D'}$$

D is negative and D' positive, since $i > 90°$ and $i' < 90°$, the first orbit being retrograde and the second direct; also $\sigma < 180°$. V is necessarily positive, but there is no positive solution of the equation unless

$$V'^2 - 2V_e V'D' > 0$$
$$V' > \sqrt{2V_e V'D'}$$

Now V'D' is the projection of V' on A'B' and

$$V'D' \gtreqless V_e \text{ according as}$$
$$A'B'C' \gtreqless 90°$$

It follows that TISSERAND's criterion is not satisfied by the two orbits, unless

$$V' \gtreqless \sqrt{2}V_e$$

But $\sqrt{2}V$ is the parabolic velocity, and, as has already been noted, such an orbit could not have been produced by a previous perturbation.

This test has been applied to orbits of meteors appearing a quarter of a year apart. I venture to suspect, however, that if a computation of the orbits were made possible by accurate observation of the velocities, it would be found that no two orbits belonging to a stationary radiant would satisfy this criterion.

VARIABLE SPOTS ON THE MOON.

By R. S. Tozer.

When the Moon first appears in the western sky after conjunction the visible portion of it does not seem to show any difference in color or shade, but, as it proceeds in its orbit, patches of light and shade begin to develop. At full Moon the contrast between these light and dark patches is at its

height, but decreases as the Moon approaches conjunction, disappearing before the crescent is entirely gone.

A portion of the lunar surface which shows these changes on a large scale is that occupied by *Tycho* and his radiating streaks. This is the most prominent feature of the full Moon when it is viewed through a low-power telescope.

It has been supposed that the streaks are enormous cracks filled up from underneath with light-colored lava, and the theory has also been advanced that they are deep ravines filled with snow and ice.

A little study of the streaks will show that there are no ravines associated with them, but that they are color-streaks only, and that they have been laid down literally on top of the hundreds of craters occupying the same territory without destroying them or changing the contour of the surface.

While the basin which forms the center of this feature is best seen when the Sun is rising on that portion of the Moon, the streaks and the dark halo surrounding the crater are not visible until some time afterward and are most distinct at full Moon.

The contrast between the so-called seas and the brighter portions is brought out most strongly at full Moon. There are also numerous smaller variable spots. These begin to darken soon after sunrise, continuing to grow darker until full Moon, and fading gradually as the Moon approaches conjunction. These changes have been attributed to the melting of snow and to the growth of vegetation on the darkening portions, but there is a very simple explanation of the matter which does not require either snow or vegetation.

When light strikes a reflecting surface at a considerable angle of incidence more of it is reflected than when it strikes perpendicularly. At a very large angle of incidence the color or shade of the reflecting surface makes little difference in the amount of light reflected, a dark surface reflecting about the same amount of light as a light one. One of the results of this is to reduce the contrast between different-colored surfaces when obliquely illuminated, while the contrast is heightened by vertical illumination. I quote from GAGE'S Physics: "For example, at perpendicular incidence water reflects about the fiftieth part of the incident light while mercury

reflects about two thirds; but at an incidence of 89½° each reflects about 72 per cent of the incident light." That is to say, that with vertical incidence mercury reflects thirty-three times as much as water, making a strong contrast between the two, but at an incidence of 89½° they would appear practically the same.

The principle may be easily proven by experiment. On a piece of white cardboard paste pieces of black paper; place it in a darkened room and project on it at an incidence of 85° or more a pencil of white light, such as the beam of a magic lantern. The light, the screen, and the observer may be so placed that no difference in color can be detected between the white cardboard and the black paper.

When the narrow crescent of the Moon first appears in the western sky at sunset it is almost on a straight line between us and the Sun. The angle of incidence is consequently very great. This angle steadily decreases as the Moon moves on in its orbit, and becomes zero at full Moon, and the differentiation of the light and dark sections increases with the decrease of the angle of incidence.

It would appear at first glance that the crescent Moon should be brighter than the same area of full Moon, while the reverse is said to be the case; but in the case of light striking a very rough surface (like that of the Moon) at a great angle of incidence the elevations will cut off considerable portions of both the incident and reflected light, but they will cut off none in the case of vertical incidence. This reduces the amount of light reflected by the crescent Moon, but it does not have any effect in showing contrast between light and dark areas.

If the Moon were a smooth body it would be brighter at its first appearance after conjunction than the same area of it at opposition.

PATTON, PA., July 27, 1905.

LANETARY PHENOMENA FOR NOVEMBER AND DECEMBER, 1905.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

First Quarter,	Nov. 3,	$5^h\ 39^m$ P.M.	First Quarter,	Dec. 3,	$10^h\ 38^m$ A.M.
Full Moon,	" 11,	9 11 P.M.	Full Moon,	" 11,	3 26 P.M.
Last Quarter,	" 19,	5 34 P.M.	Last Quarter,	" 19,	4 9 A.M.
New Moon,	" 26,	8 47 A.M.	New Moon,	" 25,	8 4 P.M.

Mercury is an evening star at the beginning of the month, having passed superior conjunction on October 12th, but is not far enough away from the Sun to be seen after sunset for ten days or so after November 1st. It comes to greatest east elongation (21° 41′) on the evening of November 26th, and then remains above the horizon not quite an hour and a half after sunset. The interval does not become less than one hour until several days after December 1st. The planet will therefore be favorably situated for evening view for three weeks or more. After December 1st the planet rapidly nears the Sun, and passes inferior conjunction December 15th becoming a morning star. It rapidly recedes from the Sun after this, and by the end of the month is well out toward greatest west elongation.. It will rise an hour and three quarters before sunrise on December 31st, and it may therefore be seen in the early morning twilight during the last few days of the year.

Venus remains a morning star, but is gradually drawing nearer to the Sun in their common eastward motion. On November 1st it rises a little more than two hours before sunrise, on December 1st an hour and a half before, and on December 31st about three quarters of an hour before. Its distance from the Sun will diminish from 23° on November 1st, to 12° on December 31st. It will move 60° eastward and 20° southward among the stars from the middle of *Virgo* through *Libra* and *Scorpio* into *Sagittarius*. It is in conjunction with *Mercury* 2° 30′ south of the latter on December 21st. *Mercury* is then almost too close to the Sun to be seen: but the superior brightness of *Venus* will make it a compara-

tively easy object, and may help in finding the fainter planet. *Venus* is still increasing its distance from the Earth, although not at so rapid a rate as during the autumn. At the end of December it will be about six times as far away as it was when in inferior conjunction in April.

Mars remains an evening star, and changes the time of its setting scarcely at all during November and December. It sets at a few minutes after 9 P. M. throughout the whole period. Its apparent distance from the Sun diminishes about 18° during this time: but whereas *Mars* was 10° south of the Sun on November 1st, it is 11° north on December 31st. This cause counterbalances the tendency to earlier setting due to diminishing distance from the Sun, and the time of the planet's setting varies only four minutes throughout the period. It moves 46° eastward and 13° northward among the stars from the eastern part of *Sagittarius* through *Capricorn* into *Aquarius*. Its distance from the Earth in millions of miles increases from 128 to 161, and its brightness diminishes about 40 per cent. It will, however, be easy to identify, as, although much fainter than before, it will be the brightest object in that part of the sky except *Saturn*, and it is readily distinguished from the latter by its ruddy color. It will be in close conjunction with *Saturn* on the night of December 25th (Christmas night), the closest approach being about equal to the Moon's diameter, *Mars* being to the north. Four days later the Moon passes both planets—*Saturn* at 9:18 P. M. and *Mars* at 2:30 A. M. on the night December 29-30th. As seen from certain parts of the Earth both planets will be occulted, but the occultations cannot be seen from the United States.

The present period will be very favorable for observation of *Jupiter*. It rises at 6:20 P. M. on November 1st, at 4:50 P. M. on December 1st, and at about 2 P. M. on December 31st. It is in opposition with the Sun on November 24th, and is consequently visible throughout nearly the entire night. It is in the constellation *Taurus*, and moves about 7° westward from a position near *Aldebaran*, α *Tauri*, to a place a little south of the *Pleiades*. At this opposition and the one occurring a year later the planet will have nearly its maximum northern declination, and will in consequence attain its highest altitude above the horizon. The Moon and planets "run high" during winter oppositions.

Saturn is in the southwestern sky in the evening. It sets shortly after midnight on November 1st, and before 9 P. M. on December 31st. It is near the western boundary of *Aquarius* and moves about 3° west and north during the month. Its conjunction with *Mars* on December 25th has already been noted.

Uranus is an evening star until December 26th, when it comes to conjunction with the Sun. On November 1st, it does not set until three hours after sunset, but even then it will be too low down for easy view by the time twilight has diminished sufficiently to allow such a faint object to be seen.

Neptune is in opposition with the Sun on the morning of December 31st.

NOTES FROM PACIFIC COAST OBSERVATORIES.

Nova Aquilæ No. 2.

Late in the evening of August 31, a telegram was received from Harvard College Observatory announcing the discovery of a new star by Mrs. FLEMING in R. A. $18^h\ 56^m.9$, Decl. $-4°\ 34'$. The telegram stated that it was of the seventh magnitude on August 18th, and fading rapidly. This is the second new star discovered in *Aquila* by Mrs. FLEMING.

Photometric measures were immediately begun here with the Rumford wedge photometer (see these *Publications,* Vol. XVII, p. 121), and have been continued to the present date. Eight comparison stars were selected covering a range of about eight magnitudes, two stars observed in the meridian photometry (*An. H. C. O.*, Vol. XXIV, 154) being included. The following table gives rough positions of the eight referred to the *Nova;* the magnitudes of the five determined in the course of the observations; and reference data. The position of the *Nova* for 1900.0 is: R.A. $18^h\ 56^m\ 48^s.5$, Decl. $-4°\ 35'\ 17''$.

	* — *Nova.*					
*	$\Delta\alpha$	$\Delta\delta$	BD.	BD.	MP.	J.D.M.
a	$-\ 56^s.9$	$+\ 29''$	$-4°.4663$	$6^m.8$	$7^m.10$	$7^m.06$
b	$-\ 3^m\ 13.7$	$-\ 16'\ 27$	$-4\ .4650$	7 .4	7 .55	7 .59
c	$-\ 13.8$	$+\ 6\ 46$	$-4\ .4668$	8 .5	.....	9 .35
d	$-\ 10.7$	$+\ 54$	....	....	.....	10 .79
e	$-\ 14.5$	$+\ 36$	....	....	.....	11 .43
f	$+\ 8.2$	$-\ 24$	....	....	.....	......
g	$+\ 0.5$	$-\ 1\ 11$	....	....	.....	......
h	$+\ 3.1$	$-\ 1\ 53$	....	....	.....	......

If the *Nova* fades so as to be beyond the power of the 12-inch before the middle of December when the field will be too low for measure, *f*, *g*, and *h* and the *Nova* will be measured with the 36-inch.

The magnitudes of *Nova* are based on the column "J. D. M." They may be reduced to any other (logarithmic) scale

by applying to the *Nova* in each observation the correction to the mean "J. D. M." value of the comparison stars employed in that observation.

G.M.T. 1905. d	Settings on *Nova*.	Comparison Stars.	*Nova*. m	Weight.	Remarks.
Aug. 31.79	4	*c*	10.32	1	Obsr. R. G. AITKEN. For check, etc.
31.84	16	*abde*	10.22	4	Good conditions.
Sept. 1.76	16	*abd*	10.70	3	Through clouds.
2.76	16	*abde*	10.45	4	Sky threatening.
3.70	16	*abde*	10.52	4	Moon.
4.72	16	*d*	10.46	3	Moon, smoke.
5.68	12	*d*	10.46	2	Moon, smoke. Seeing variable.
6.69	12	*d*	10.29	2	Moon. Smoke high and uneven.
7.71	12	*d*	10.66	2	Moon shining on objective.
10.68	12	*de*	10.73	3	Moon.
11.71	8	*abcde*	10.63	2	Moon.
12.73	..	(*d*)	....	..	Usual brightness.
13.70	..	(*d*)	....	..	Usual brightness.
14.70	6	*d*	10.68	1	Moon.
15.71	6	*abcde*	10.75	1	Moon.
16.74	..	(*d*)	....	..	Usual brightness.
18.71	..	(*d*)	....	..	Usual brightness.
19.72	8	*abcde*	10.89	2	Good conditions.
20.69	8	*abcde*	10.90	2	Good conditions.
22.68	29	*d*	10.96	5	Clouds threatening.

I have used the term "weight" accurately, indicating merely the *number* of observations or groups of four settings, the weight being modified, as on the 8th, when it was thought that a smaller number of observations made under normal conditions would have yielded a result of the same reliability. The effect of moonlight is very small and no correction has been made for it.

The rate of decline is now about one magnitude a month; but my observations of the first week show an unmistakable increase of brightness of nearly half a magnitude. This oscillation and the other observations can be represented fairly well by a curve of eight days' period.

September 23, 1905. JAMES D. MADDRILL.

NOTE ON THE SPECTRUM OF *NOVA AQUILÆ* No. 2.

Nova Aquilæ No. 2 was observed visually with the one-prism spectrograph on the night of September 5th, when its magnitude was about 10.5 on the Harvard scale. At that time

the spectrum was similar to that of *Nova Geminorum,* as observed by Drs. REESE and CURTIS on April 1, 1903. (See *L. O. Bulletin,* Vol. II, No. 37, pp. 59, 60.) The spectrum consisted of a number of bands, the brightest of which was easily identified as H_β by means of the neighboring iron lines in the iron spark. A faint band in the region of λ 4600, and the still fainter $H\gamma$ band, could also be distinguished. A series of maxima extending from the region of H_β toward the red, giving almost the appearance of a continuous spectrum, was also observed. The seeing was poor and the image very faint, due to a great amount of smoke in the air, making the identification of the various bands (with the exception of H_β) quite difficult.

Although the *Nova* was very faint, two fair spectrograms of it were obtained with the one-prism spectrograph, as follows:—

Plate.	Date, G.M.T.	Exposure.	Slit Width.	Emulsion.
3986A	1905 Sept. 6.8	3 hours	.004 inch	Seed 27
3994A	1905 Sept. 10.7	4 hours	.004 inch	Seed 27

The plates, in the region common to the visual and photographic rays, confirm the observations of the 5th of September. The exposure time was about correct for the H_β band, and much too short for the others. The following is a brief description of the bands and their approximate wave-lengths, which were obtained by interpolation from the iron comparisons lines.

H_β band: Strong; limits, λ 4845–4885; edges fairly sharp.

Band at λ 4600: Intensity about one fifth that of H_β; limits not sharply defined, but approximately from λ 4590–4710; fades off gradually on both sides.

$H\gamma$ band: Intensity one tenth (or less) that of H_β; width 50–60 A. U.; sharp minimum at λ 4345.

H_δ band: Very faint; width about 70 A. U.

A faint continuous spectrum extends from the region λ 4500 to that of the $H\gamma$ band. H_ϵ and the so-called nebular lines, with the possible exception of λ 5007, do not show on the plates.

It will be noticed that the relative photographic intensities given above are very unlike those of *Nova Geminorum* in 1903 (l. c.). While this may be due to a real difference in the stars,

we are at present unable to say to what extent it has been accentuated by differences in the emulsion and atmospheric conditions.

J. H. MOORE,
S. ALBRECHT.

1905, September 30th.

PHOTOGRAPHS OF *NOVA AQUILÆ* NO. 2.

Photographs of *Nova Aquilæ* No. 2 have been obtained with the Crossley reflector since August 31st, with exposures ranging from ten seconds to two and one-half hours. No indication of any nebulosity surrounding the *Nova* is shown on these plates. The photographic magnitude on August 31st was about 9.2 on the DM. scale, and by September 4th it had faded several tenths of a magnitude.

The following position of the *Nova* was obtained from a plate taken on October 1st with an exposure of ten seconds:—

$$\alpha\ 1905.0 = 18^h\ 57^m\ 4^s.8$$
$$\delta\ 1905.0 = -4^\circ\ 34'\ 53''$$

S. ALBRECHT.

PROGRESS OF WORK AT MOUNT WILSON.

Director HALE, of the Solar Observatory at Mount Wilson, is in Europe, and the other members of the staff find their time so fully occupied that notes on the work must wait until later.

A letter from Professor RITCHEY, however, from which I am permitted to quote, states that satisfactory progress is being made both in the construction of instruments and buildings and in the work of actual observation. Arrangements are now being made for the erection of a dome for the five-foot reflecting telescope.

Professor BARNARD, of the Yerkes Observatory, who has been at Mount Wilson since last January, has completed his series of photographs of the Milky Way, and has dismounted the Bruce photographic telescope preparatory to his return to Williams Bay.

The Smithsonian Expedition, under Professor ABBOT, which has been carrying on investigations on solar radiation at Mount Wilson, during the past summer, still occupies its station, but will complete its programme in a few weeks.

Professor HALE is expected to return to the observatory about October 20th.

R. G. A.

THE SOLAR ECLIPSE OF AUGUST 29-30, 1905.

Detailed reports from the Crocker Eclipse Expeditions from the Lick Observatory have not yet been received, but cable messages from Director CAMPBELL, at Alhama de Aragon, Spain, and Professor HUSSEY, at Assouan, Egypt, state that the entire programme was successfully carried out. At the Labrador station, according to a message from Dr. CURTIS, the eclipse was not seen, owing to storms which apparently extended over a wide area. Dr. CAMPBELL states that the corona had no prominent streamers, but was circular, as in 1893. In our December issue we hope to print a general account of the three expeditions from this Observatory, with illustrations. Press dispatches report successful results at all stations along the path of the eclipse from Spain to Egypt.

R. G. A.

THE MOTION OF 13 *CETI* = Hο 212.

Three recent observations of this interesting binary system show that the companion star is now in the third quadrant. The mean of these measures is:—

1905.60 208°.2 0″.13 3^n 36-inch

The two components were distinctly separated at the time of the third observation, and as they differ very decidedly in magnitude there is no doubt about the quadrant. Dr. SEE measured this pair at Washington on one night in 1899.97, obtaining 250°.7 0″.28, a result which was confirmed here the following year, when three nights' measures with the 36-inch gave the position—

1900.70 261°.0 0″.21

As my measures since 1900 have shown that the motion is direct,—that is, that the position-angles increase with the time,—it appears that the companion star has described an arc of fully 300° about its primary in less than *six* years. It is therefore now certain that 13 *Ceti* must rank with δ *Equulei* and κ *Pegasi* as one of the most rapid of known visual binaries; in fact, an orbit with a period of 7.1 years will represent all the observations satisfactorily, and will also account for BURNHAM'S failure to see the companion in 1877 and in 1890-91.

R. G. AITKEN.

September 25, 1905.

Observations of the Seventh Satellite of *Jupiter*.

Plates of the seventh satellite of *Jupiter* have been obtained with the Crossley reflector since August 5th. The plates taken on the nights of August 7th, 8th, and 9th gave the following approximate positions for the satellite, referred to the ephemeris positions of *Jupiter* taken from the American Ephemeris (*Jupiter* being off the edges of the plates):—

Date.	Length of Exposure.	Distance.	Position Angle.
August 7.96	90^m	54'.6	289°.7
8.96	90	55 .1	289 .5
9.96	90	55 .6	289 .4

These observations show the satellite to be about a month ahead of the ephemeris computed for it by Dr. Frank E. Ross (*L. O. Bulletin*, 78).

The satellite is of about the sixteenth photographic magnitude.

Seb. Albrecht.

August 14, 1905.

A Curious Astronomical Observation.

While engaged at the 12-inch telescope, about thirteen minutes before noon, September 19th, I chanced to see a bright object moving in a northeasterly direction in the field of the finder. The telescope being only lightly clamped, I was able to follow the object for about eight or ten seconds, when it was cut off by the dome. Calling to a visitor to move the dome quickly, I attempted to keep the telescope moving with constant speed and direction. On the aperture's clearing again, however, I did not find the object readily. I then noted the position of the telescope: R. A. 14^h 0^m, Decl. + 16°.5. It was near R. A. 13^h 46^m, Decl. + 14°.8, when the slowly moving meteorite was first seen. The time in traversing this estimated path would have been about fifteen or twenty seconds. Hence, roughly, the apparent velocity was only about 10' or 15' per second.

Turning immediately to *Venus*, I noted that the meteorite was somewhat brighter than *Venus*, its intrinsic luster being less, but its apparent area being five or ten times as great.

No trail was seen with certainty; my attention was directed to the nucleus.

Care was taken to determine definitely that the phenomenon was not one of reflected sunlight, etc.

September 23, 1905. JAMES D. MADDRILL.

GENERAL NOTES.

In number 100 of these *Publications* there was printed a table showing a comparison between the weather at the International Latitude Stations of Mizusawa, Japan, and Ukiah, California. The Mizusawa meteorological report for 1904 came recently, and a comparison similar to that published in the number mentioned above is given in the table below:—

	Mizusawa.	Ukiah.
Precipitation (1904)	54.84 inches	56.02 inches
Maximum	12.58 (July)	17.29 (Feb.)
Minimum	1.39 (Feb.)	0.02 (Aug.)
Number of days on which rain fell	211	98
Number of days on which no rain fell	155	268
Maximum interval with rain every day	Oct. 26–Nov. 11 (17 days)	Mar. 5–Mar. 14 (10 days)
Maximum interval without rain	Aug. 14–Aug. 29 (16 days)	July 14–Aug. 23 (40 days)
Number of clear days........	12	201
Number of cloudy days.......	170	96
Maximum temperature	93° F. (Aug.)	108° F. (Aug. Sep.)
Minimum temperature	–4° F. (Jan.)	25° F. (Jan. Mar.)

Besides the meteorological data, the report contains two seismological tables, one containing the records of ninety-nine earthquakes, and the other the records of sixty-seven pulsatory oscillations, all experienced at Mizusawa in 1904.

Names for Satellites.—The August number of *The Observatory* contains a communication from CHAS. T. WHITMELL which reads as follows:—

"Whilst the members of the ever-increasing crowd of minor planets are promptly supplied with names, we have, as yet, no name for the satellite of *Neptune*, discovered nearly sixty years ago; and for the satellite of *Jupiter*, discovered in 1892, we have only a number. Now that fresh members have been added to the families of *Jupiter* and *Saturn*, the lack of distinctive names, such as those so happily given to the satellites of *Mars*, is a decided inconvenience.

"Should not the discoverers of these recently found moons be asked to name them? Their right to do so will not be disputed. In the case of *Neptune's* moon, unfortunately we cannot appeal to Mr. LASSELL; but if this satellite may not

bear his name, would it not be well for leading astronomers (at their next conference) to find some suitable title?"

The following notes have been taken from recent numbers of *Science*:—

At the recent commencement of Amherst College the degree of Master of Arts was conferred by President HARRIS on Mr. LUNDIN. He said: "CARL AXEL ROBERT LUNDIN, scientific expert in cutting and fashioning glasses of great telescopes. He has done important work on the large objectives of Russia, of the Lick and Yerkes observatories, and lately on the 18-inch objective of the Amherst College Observatory, which is wholly his work. In 1854 Ahmerst conferred the degree of master of arts on ALVAN CLARK, who had built our first telescope. The same degree, for a similar service, is conferred on his successor, who has kept pace with the progress of astronomical science."

The city of Hamburg will re-establish the old astronomical observatory at Bergedorf. The observatory has been presented with fifty thousand marks for the purchase of a photographic telescope.

The Carnegie Institution sent Professors F. ELSTER and H. GEITEL and Herr F. HARMS to Palma to make observations of the electric conditions of the atmosphere during the recent solar eclipse. *Nature* states that by means of a self-registering electrometer, the variation of atmospheric electricity was photographically recorded, and a series of points of the same curve was taken simultaneously by eye-readings. The ionization of the air was studied, and exact measurements of the intensity of the solar radiation within the short wave-lengths were carried out. The observations, like all others in Spain, suffered from bad weather conditions. On the day of the eclipse rain fell during the morning: consequently it cannot be considered as undisturbed as regards atmospheric electricity. The measurements of the solar radiation were possible in a continuous series only from the first contact to the end of totality; the decrease of illumination, therefore, was determined in a satisfactory manner and without any gaps. On the other hand, clouds prevented any reading being taken during the increase of light after totality.

Darwin's Address.—Professor G. H. DARWIN's presidential address, on evolution, delivered before the recent meeting of the British Association for the Advancement of Science held in South Africa, is printed in full in *Science* for August 25th and September 1st. It is a masterly address, and should be read by every one interested in astronomy.

Doctor's Degrees.—In *Science* for September 15th there appeared an article entitled "Doctorates Conferred by American Universities." During the last eight years 2,037 doctorates have been conferred, and of these 984 were taken in the sciences. Astronomy stands ninth among the twenty-two sciences enumerated, with twenty-seven degrees to its credit. Three doctorates in astronomy were conferred during the last academic year as follows: "By Princeton University, on WALTER MANN MITCHELL, "Researches in the Sun-Spot Spectrum, Region F-A"; by the University of Wisconsin, on STEPHEN MARSHALL HADLEY, "Relative Masses of Binary Stars"; by the University of California, on RALPH HAMILTON CURTISS, (I) "A Method of Measurement and Reduction of Spectrograms for the Determination of Radial Velocities," (II) "Application to the Study of the Variable Star *W Sagittarii.*"

Latitude Stations.—In the last number of these *Publications* there appeared a note on the variation of latitude in which mention was made of two new stations about to be established in the southern hemisphere. Since that note was written additional data have come to hand which may not be entirely without interest to readers of these *Publications*. The exact latitude of the stations is $-31^\circ\ 55'\ 15''$, and the longitudes are $-115^\circ\ 54'.5$ and $+63^\circ\ 42'$. The Australian station is situated near Bayswater, between three and four miles northeast of Perth, the principal city of Western Australia. Perth has about forty thousand inhabitants. The altitude of the station is about one hundred feet above sea-level. The annual range of temperatures is between freezing and 110° Fahrenheit, and the yearly rainfall is about thirty-four inches. Dr. CURT HESSEN, formerly second assistant in the Berlin Observatory, is to be observer at this station, and the instru-

ment is a zenith-telescope by WANSCHAFF of 2.7 inches aperture and 34 inches focal length. This is the instrument used by MARCUSE in the observations made at Honolulu in 1891 and 1892.

The station in the Argentine Republic is located near the small village of Oncativo, which is on the Central Argentine Railway about forty-three miles from Cordoba. The altitude of the station is about 920 feet. The annual range of temperature is between + 20° and + 105° Fahrenheit. The yearly rainfall is about 27.5 inches. Dr. LUIGI CARNERA, for two years observer at the latitude station at Carloforte, is to have charge of this station. The instrument is a zenith-telescope by WANSCHAFF of 4.3 inches aperture and 51 inches focal length. This instrument is of the same size as those at Gaithersburg and Ukiah.

With the establishment of the new zenith-telescope at the Poulkova Observatory, mention of which was made in the last number of these *Publications*, regular observations for the variation of latitude are now being made at eleven different stations situated in five different latitudes, as follows: Poulkova, in latitude + 59° 46′; Leiden, + 52° 9′; Mizusawa, Tschardjui, Carloforte, Gaithersburg, Cincinnati, and Ukiah, + 39° 8′; Tokio + 35° 39′; Bayswater and Oncativo, — 31° 55′.

S. D. T.

The Figure of the Sun.—The *Astrophysical Journal* for September contains a number of interesting articles, one of which, "The Figure of the Sun," by CHARLES LANE POOR, is of special and perhaps popular interest. Between 1860 and 1875 LEWIS M. RUTHERFURD made a large number of photographs of the Sun, and these negatives are now in the possession of the Observatory of Columbia University. Dr. POOR has selected from these all of those which are of good definition and have upon them marks and data sufficient for their orientation. Most of the plates did not have orientation marks upon them, and only twenty-two were found suitable for measurement. The polar and equatorial diameters of the Sun's image were determined from these plates by means of a measuring-engine, and when the results were arranged chronologically the interesting fact developed that the number which

expresses the ratio between the polar and equatorial diameters is not constant, and indeed it was found that the equatorial diameter was sometimes greater and at other times less than the polar diameter. In order to test the result Dr. POOR made an investigation of a large number of heliometer measures of the Sun's diameter made in connection with the transits of *Venus* in 1874 and 1882. This investigation confirmed the results obtained from RUTHERFURD'S plates. To still further test the result Dr. POOR obtained a number of negatives of the Sun taken at Goodsell Observatory in 1893 and 1894. The measurement of these plates gave further confirmation of the result first obtained.

Dr. POOR'S next step was to plot these results along with the curve of sun-spot frequency, and the interesting fact was developed that the change in the ratio between the equatorial and polar diameters has a period which apparently coincides with the sun-spot period. The equatorial diameter increased with respect to the polar diameter at the same time that the number of spots was increasing, and *vice versa*.

The article is closed with the following paragraphs: "The present investigation would seem to show, therefore, that the ratio between the polar and equatorial radii of the Sun is variable, and that the period of this variability is the same as the sun-spot period. The Sun appears to be a vibrating body whose equatorial diameter, on the average, slightly exceeds the polar diameter. At times, however, the polar diameter becomes equal to and even greater than the equatorial—the Sun thus passing from an oblate to a prolate spheroid.

"In this variable figure of the Sun may lie the explanation of the anomalies in the motions of *Mercury, Venus*, and *Mars*."

S. D. T.

Eclipse from a Balloon.—Mr. PERCIVAL SPENCER gives the following account of the balloon ascent which he made with Mr. F. H. BUTLER from Wandsworth, near London, with the object of viewing the eclipse from the clouds:—

"At half-past 12 the ascent commenced, and at 12:40 through the upper clouds we saw the Sun, a crescent. We were then two thousand feet high, and still rising. Soon more clouds intervened, and in another five minutes we had

reached three thousand feet, and the Sun was quite obscured by the upper clouds. The balloon was now reaching its equilibrium, and at ten minutes to 1 a hundredweight of sand was discharged, which had the effect of so lightening it that a continual and regular rise ensued. At five minutes to 1 we were forty-five hundred feet high, saw the eclipse well, and took our first photographs of it. From 1 o'clock to twenty minutes past we had a continual and uninterrupted view, and proceeded to take photographs at regular intervals, until at 1:30 we had reached six thousand feet high, and now so much cloud had been left behind that we found the light so strong that the view could not be obtained with our obscured glasses. The Sun's rays were too powerful. We overcame this by using two glasses, and thus we not only continued to view the increasing rays, but continued to take photographs, with our fumed glasses in front of the lens. . . . The eclipse finished at 2:04, and one minute later the balloon descended through the clouds. As we passed the clouds, snowflakes descended round us; at 2:10 we were crossing the coast-line, and at a quarter past 2, having dropped to three thousand feet, we were out at sea. At 2:25 the coast was disappearing. By means of the statoscope—a delicate instrument for showing the rise and fall—we endeavored to maintain our equilibrium at about three thousand feet."

The aeronauts landed at Caen, having traveled one hundred and sixty miles in seven and a half hours.—*Extract from the Times.*

Solar Eclipse.—M. Trépied, director of the Algiers Observatory, reported as follows concerning the recent eclipse:—

"The observation was favored by splendid weather, and the sky was very clear. The contact of the Sun and Moon occurred practically at the moment determined by the calculations made in different countries.

"As soon as the light began to fail *Mercury, Regulus,* and *Venus* were seen shining in a dark sky. The solar corona was very brilliant. It presented, on the whole, the features which had been expected on account of the period of solar activity, i. e. the corona was not very extensive, but was distributed uniformly round the Sun. Brilliant red protuberances

of hydrogen were perceived on the edge of the Sun at the beginning and at the end of the period of totality. BAILEY'S beads were also observed.

"The Algiers mission took thirty-one photographs of the eclipse before, during, and after the period of totality. It photographed the spectral corona with a special apparatus. The temperature fell five degrees centigrade, from 33 to 28 (91.4 to 82.4 Fahrenheit). The wind was rather strong. The so-called eclipse wind rose at the beginning of totality and of obscurity. At the same time we saw on the ground moving shadow-stripes, a phenomenon which has not yet been explained."—*From London Standard.*

MINUTES OF THE SPECIAL MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, AUGUST 31, 1905, AT 8 P. M.

The meeting was called to order by Vice-President LEUSCHNER. A quorum was present. The minutes of the last meeting were approved

Resolved, That the Laws Observatory, University of Missouri, be placed upon the list of corresponding institutions.

The Society receives gratis the numbers of the Bulletin of the Laws Observatory.

The Treasurer reported that, by order of the Finance Committee, the fourteen savings-bank accounts of the Permanent Funds (see Annual Statement, No. 101, page 87) have been distributed as follows:—

Life Membership Fund	$918 83	with	German Savings and Loan Society.
Montgomery Library Fund . . .	438 33	"	Security Savings Bank.
Donohoe Comet-Medal Fund . .	760 74	"	San Francisco Savings Union.
Bruce Medal Fund	671 08	"	Mutual Savings Bank.
John Dolbeer Fund	985 50	"	Union Trust Company.

AMENDMENT TO THE BY-LAWS.

The following amendment to the by-laws was duly adopted by the consenting votes of nine Directors, namely: Messrs. AITKEN, BABCOCK, BURCKHALTER, CAMPBELL, CROCKER, CUSHING, LEUSCHNER, TOWNLEY, ZIEL.

ARTICLE II.

This Society shall consist of patrons, active members, and life members, to be elected by the Board of Directors.

1. Persons who render distinguished services to the Society may be designated as patrons of the Society. The consenting votes of eight members of the Board of Directors shall be necessary for election to this status. Such election shall carry with it election to life membership in the Society and the privileges attached thereto.

2. Active members shall consist of persons who shall have been elected to membership and shall have paid their dues as hereinafter provided.

3. Life members shall consist of persons who shall have been elected to life membership and shall have paid $50 (fifty dollars) to the Treasurer of the Society.

4. A certain number of observatories, academies of science, astronomical societies, institutions of learning, etc., not to exceed one hundred, shall be designated by the Board of Directors as corresponding institutions, and they shall receive the publications of the Society in exchange or otherwise.

The following resolutions were duly adopted by the consenting votes of the above-named nine Directors:—

Resolved, That the following names be placed on the list of Patrons of the Society:

PATRONS OF THE SOCIETY.

EDWARD SINGLETON HOLDEN . . . . . West Point, N. Y.
JOSEPH A. DONOHOE.†
ALEXANDER MONTGOMERY.†
CATHERINE WOLFE BRUCE.†
JOHN DOLBEER †
WILLIAM ALVORD.†
WILLIAM MONTGOMERY PIERSON.†

† Deceased.

Resolved, That the Bruce Medalists shall be entitled to receive the publications of the Society gratis.

Resolved, That the Publication Committee be instructed as follows: Whenever a list of members of the Society is published, there shall be printed, first the names of the "Bruce Medalists," under that heading and in the order of the bestowal of the medal. This shall be followed by the names of the "Patrons of the Society," under that heading and in the order in which the distinguished services were rendered. These lists shall be followed by the names of "Members of the Society," under that heading, arranged in alphabetical order. The names of deceased Patrons and of Bruce Medalists shall be continued on the lists.

Adjourned

OFFICERS OF THE SOCIETY.

Mr. S. D. Townley . . . . *President*
Mr. A. O. Leuschner . . . . *First Vice-President*
Mr. Chas. S. Cushing . . . . *Second Vice-President*
Mr. A. H. Babcock . . . . *Third Vice-President*
Mr. R. G. Aitken, Mr. F. R. Ziel . . . . *Secretaries*
Mr. F. R. Ziel . . . . *Treasurer*

Board of Directors—Messrs. Aitken, Babcock, Burckhalter, Campbell, Crocker, Cushing, Hale, Leuschner, Pardee, Townley, Ziel.
Finance Committee—Messrs. Cushing, Leuschner, Wm. H. Crocker.
Committee on Publication—Messrs Aitken, Townley, Newkirk.
Library Committee—Mr. Crawford, Miss O'Halloran, Miss Hobe.
Committee on the Comet-Medal—Messrs. Campbell (*ex-officio*), Burckhalter, Crocker.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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(February, April, June, August, October, December.)

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COMMITTEE ON PUBLICATION.

ROBERT G. AITKEN, Mt. Hamilton, Cal.
SIDNEY D. TOWNLEY, Ukiah, Cal.
BURT L. NEWKIRK, Berkeley, Cal.

GENERAL VIEW OF THE CAMP OF THE LICK OBSERVATORY-CROCKER ECLIPSE EXPEDITION, AT CARTWRIGHT, LABRADOR.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. XVII. SAN FRANCISCO, CALIFORNIA, DECEMBER 10, 1905. No. 105.

THE LICK OBSERVATORY-CROCKER ECLIPSE EXPEDITION TO LABRADOR.

BY HEBER D. CURTIS.

In accordance with the plans of Director CAMPBELL (cf. *Lick Observatory Bulletin* No. 59) to utilize three stations as widely separated as possible for the study of problems of coronal motion and of possible intramercurial planets at the total solar eclipse of August 30, 1905, it was decided to place one of the three eclipse expeditions sent out by the Lick Observatory, University of California, through Mr. WM. H. CROCKER'S generosity, at some point on the coast of Labrador. The actual difference in time between the instants of totality on the coast of Labrador and at the Egyptian station was about two and a half hours, and the value of large-scale photographs of the corona separated by this interval of time from the eastern stations was felt to more than counterbalance the risk of unfavorable weather conditions which would undoubtedly be quite large in such a climate as that of Labrador.

The Labrador party consisted of the writer and Dr. JOEL STEBBINS, formerly Fellow at the Lick Observatory and now Assistant Professor of Astronomy at the University of Illinois. Mrs. CURTIS and Mrs. STEBBINS accompanied the expedition, which sailed from New York for St. Johns, Newfoundland, on July 8th, via the Red Cross Line steamer "Rosalind." The only method of reaching the Labrador is by the little mail steamer "Virginia Lake," of the Reid-Newfoundland Company, which sails every two weeks or so from St. Johns. It was found on reaching Halifax that the somewhat elastic schedule of this steamer had been changed so as to leave St. Johns on the 13th of July, instead of on the 20th, as we had expected.

This was the date of the arrival of the "Rosalind," so that it was necessary to make a very hurried transfer of freight at St. Johns and to forego, to the great regret of the party, the pleasure of a visit with Sir WILLIAM MACGREGOR, Governor of Newfoundland, who had invited the four members of the expedition to be his guests at Government House during their stay in St. Johns. We are indebted to the Newfoundland Government for the free entry of all our goods and instruments, and to Governor MACGREGOR for so expediting the customs formalities that we were not delayed in the slightest in our transfer to the Labrador steamer. To Mr. H. A. MORINE, General Passenger Agent of the Reid-Newfoundland Company, we are greatly indebted for his consent to hold the "Virginia Lake" for the transfer of our freight. Had we missed this connection at St. Johns, we should not have reached our station till August 5th instead of on July 18th. The trip from St. Johns to Cartwright, Sandwich Bay, Labrador, occupied nearly five days, and was full of novel experiences, though quite cold and with much rain and fog. Literally hundreds of icebergs were passed, one of them, an enormous mass, toward which we were steering through the thick fog of a dark night, being much too close for comfort. Considerable floating pan-ice was passed as well, and before the little steamer could reach her most northern ports of call, at the Moravian mission stations of Hopedale and Nain, she had to force her way through five miles of pack-ice. This was the first trip of the season in which she had been able to reach these northern points at all. Snow still lay in many of the gullies down to the water's edge, for the Atlantic Labrador is much colder than the corresponding latitudes on the western coast of the continent, owing to the cold Arctic current which brings the bergs and pack-ice down from the north. The amount of ice brought down by the current this summer was declared by those of long experience on the coast to be unprecedented, and must be taken into account as one of the causes of the unusual amount of bad weather which the summer afforded.

Every effort had been made before starting to select the best location as regards weather conditions, and Cartwright, on Sandwich Bay, had been tentatively selected, subject to change, should evidence favor another location. Letters from

men of long experience on the coast spoke of the dangers from fog, and agreed that the harbor of Cartwright, somewhat sheltered and removed as it is from the open sea, was far more apt to be free from fog than more eastern and exposed spots. There are no meteorological data for this bleak coast save the rather general records of the Hudson's Bay Company. Navigators of experience state that it is not infrequently clear in Sandwich Bay when thick outside. On the trip to the Labrador, also, no opportunity was lost to interview numbers of old fishermen of from twenty to fifty years' experience on the coast, and their evidence was all to the same end; that the eastern and more exposed spots were much more subject to storm and fog than places to the north and west, particularly when somewhat removed from the open ocean. Spotted and Square islands, among the most easterly of the coast points, are stated to be extremely subject to fog. The interior, on the other hand, is subject to very rainy and stormy weather in summer. The Hudson's Bay Company post at Northwest River, at the head of Hamilton Inlet, over one hundred miles from the sea, is almost centrally located on the path of the eclipse, but the records kept there show that the last week in August has been wet and stormy every year for the past ten years. The geography used in the Newfoundland schools states that "Cartwright is noted for its mild and pleasant climate as compared with the surrounding region." Accordingly no evidence was found to change the tentative selection of Cartwright, which had been made before starting.

Cartwright is pleasantly located on a landlocked arm of Sandwich Bay; its surroundings are not devoid of natural beauty, and consist of low mountains covered with stunted pines, a pleasant change from the uniformly cheerless, treeless, and rocky headlands of the coast. The scenery on the Labrador is often grand and impressive, but probably as bleak and desolate as that of any coast on the globe. Cartwright is a post of the Hudson's Bay Company, and consists of but a few houses and huts, aside from the storehouses and other buildings of the company. It has a permanent population of about sixteen, a number which is swelled to fifty or sixty in summer, when the "liveyeres" come down from their winter quarters at the head of the bay to engage in salmon-fishing.

We were fortunate enough to have had as fellow travelers on the "Virginia Lake" two men high in influence in the affairs of the Hudson's Bay Company, Dr. A. MILNE, Assistant Commissioner, of Winnipeg, and Mr. PETER MACKENZIE, with a record of fifty years' service in "the silent places," and now Chief Factor of the St. Lawrence and Labrador Districts. These gentlemen placed at our disposal the Company's resources at Cartwright, and their general orders were most ably and willingly seconded by Mr. W. E. SWAFFIELD, the Hudson's Bay Company Agent at this post.

The winter quarters of the company's servants were offered us by Mr. SWAFFIELD. All tents, camp supplies, and provisions had been brought from New York. This little old house was a veritable treasure-trove, however, furnishing us with a kitchen, a combined pantry and dark-room, and a general storeroom. The great box stove formed the nucleus of our camp life during the cold, subarctic summer, though the heavily raftered ceiling was built so low, to economize heat against the winter temperatures of 60° or 70° below zero, that the tallest member of the expedition had innumerable causes of temporary regret at his inches. The site for the camp was chosen directly behind and to the west of this house.

Considerable difficulty was experienced at the start in procuring labor. The expedition reached Cartwright at the middle of the salmon run. This is the main means of support for these fishermen, and most of them earn enough in the two or three weeks of the run to support them for the balance of the year, one hundred and twenty or one hundred and fifty dollars being quite fair annual wages, on the Labrador standard. It would have been impossible for the first week or two to have hired men for twenty-five dollars per day, as not infrequently more than this might be made on a favorable day of the run. Considerable of the work of establishing the camp and clearing off some of the timber was therefore done by the members of the expedition. Later two fishermen gave up their cod-fishing to work for the expedition, and a third was employed at intervals.

A difficulty of quite another sort was found in the justly famous Labrador flies and mosquitoes. We had read much in advance about these pests, and the reception they gave us

was fully as vigorous as we had anticipated. The little black flies delight to crawl up the sleeves or under the clothing and bite out a small chunk. The "stout," or "bull-dog," is the size of a large horse-fly, and stops at nothing when hungry. The mosquitoes are most voracious and in numbers uncountable. We spent some time in experimenting with various fly ointments, most disagreeable to use and at best but temporary in the relief afforded, and finally managed to work in comfort out of doors only by the use of leather gloves, wristlets, and rather elaborate head-nets of fine mesh, fastened to wide straw hats and tied tightly about the neck or shoulders. With these precautions we found it possible to work in comparative comfort in the midst of these buzzing swarms of insect pests. Work in the open was otherwise impossible. It was with considerable elation that we proved the possibility of taking sextant observations through the head-net.

The work of installing the instruments was accomplished, with time to spare, in spite of the very heavy run of bad weather. The larger buildings of the Hudson's Bay Company are arranged to catch the rain-water from the roofs, and so wet was the summer that Mr. SWAFFIELD states that this was the first time in eight years that he had not had to import water from a creek some distance from the post across the bay. All the water used at the camp after the first two weeks had to be imported in this fashion, by boat. It was early realized that the chances of a successful eclipse were very much poorer than had been anticipated, due to the unusual amount of bad weather, caused doubtless by the great quantity of ice coming down from the north. It had been hoped that the chances of success would be at least one in two, but the meteorological records which we kept show that the number of good eclipse days was in much smaller proportion. The following data give a brief summary of the weather conditions experienced.

Number of days on which observations were taken, July 18th-September 6th	50
Number of days clear or nearly so at 8:06 A. M.	13
Number of days on which a few results might have been secured	7

Proportion of "good" eclipse days, about one in four.

Maximum recorded temperature, 73°.

Minimum recorded temperature, 34°.

(A little ice and much frost on several nights in August.)

Governor MacGregor had planned a scientific expedition along the Labrador coast with the intention of making accurate determinations of the latitude and longitude of a number of reference-points in this poorly surveyed region. A battery of chronometers and a number of theodolites, chronographs, and other instruments were provided for this purpose, for which Governor MacGregor is particularly well fitted through the work he had already done in this line while in charge of the colonies of British New Guinea and of Lagos in the British West Africa Protectorate. The Governor and his assistants reached Cartwright on August 8th in the government yacht "Fiona," piloted by Dr. Grenfell, with the British cruiser "Scylla," under Commodore Sir Alfred Paget, as convoy. Governor MacGregor was favored with a clear night, and secured a complete and extended set of observations for latitude and longitude. The reductions of the latter coordinate have not yet reached the writer; that for the latitude is given below. We were glad also to have as visitors to the camp Secretary of State Elihu Root and party. It may not be generally known that Mr. Root, as a young man, was member of an eclipse expedition in charge of the late Professor Peters, Director of the observatory at Hamilton College, of which institution Mr. Root is an alumnus.

The coordinates of Cartwright, and the computed data for the eclipse, are as follows:—

Longitude, $3^h\ 47^m\ 59^s$ W. (Admiralty chart).

Latitude $53°\ 42'\ 31''$ N. (Sir Wm. MacGregor).

First contact,	7^h	3^m	12^s	A. M., local mean time.
Second "	8	5	37	
Third "	8	8	7	
Last "	9	15	6	

Sun's apparent altitude at mid-eclipse, $25°\ 44'\ 35''$.

Duration of totality, $2^m\ 30^s$.

With the four intramercurial cameras it was planned to take two plates with each camera, having an exposure time of about 65^s apiece, allowing twenty seconds for the change of plates at the middle of totality and the cessation of vibration in the instrument caused thereby. This margin was more than enough, as the change was not infrequently made in the preliminary drills in ten seconds. For three of the cameras the plates used were sixteen by twenty inches; and for the fourth, which pointed to the region of the sky nearest the horizon, the plates were fourteen by seventeen inches. The driving-clock was rated to solar time. The lenses were three inches in diameter, by eleven feet three inches focal length.

The exposures for the large-scale photographs of the corona to be taken with the 41-foot lens were arranged as follows:—

½	second	14 x 17	
1	"	14 x 17	"Standardized" at Mt. Hamilton.
4	"	14 x 17	
8	"	14 x 17	"Standardized" at Mt. Hamilton.
64	"	18 x 22	
16	"	18 x 22	"Standardized" at Mt. Hamilton.
8	"	14 x 17	
2	"	14 x 17	

The Sunday and Monday preceding the eclipse were the best days we had seen on the Labrador; the seeing was particularly good. Tuesday, the 29th, however, opened with the worst gale of the season; the wind was so high that anxiety was felt for the safety of the tower of the 41-foot camera. The "Scylla" had returned to Cartwright on the 28th, and it was feared that the "Fiona" and Dr. GRENFELL in his "Strathcona" might not be able to reach the harbor, but they did. Rain fell nearly all the night of the 29th, but there was a lull in the storm on the morning of the 30th, the wind shifting from north to west, and affording a fleeting view of the crescent Sun about half an hour before totality. But at the time of the total eclipse the densest of clouds covered the Sun, so that not a vestige of the eclipse could be seen. The storm sprang up again in the afternoon and lasted for five days after the eclipse. Data from all possible sources indicate that this gale was of great extent, and that stormy conditions were the rule all over the coast and far inland from the 29th

of August to the 5th of September. The slight break in this gale, however, which came on the morning of the 30th, was sufficient to afford a view of the eclipse at several Labrador points. Fishermen saw it through a rift in the clouds at Paradise, twenty miles southwest. It was clear, at the time of totality, at Indian Tickle, on the coast some twenty-five miles east of Cartwright. At Northwest River, one hundred miles inland, where the English and Canadian parties were located, it was raining at the time of the eclipse. So, aside from the magnetic results secured at the stations established by the Carnegie Institution, the scientific results from Labrador were *nil*.

The personnel of the camp at the time of the eclipse was as follows:—

Forty-one foot camera—Dr. JOEL STEBBINS, Assistant Professor of Astronomy, University of Illinois; Mr. W. TAYLOR REED, formerly Assistant Professor of Astronomy at Princeton University.

Intramercurial cameras—Mr. E. F. HARVEY, of St. Johns, at the exposing screen; Camera No. 9, Sir ALFRED PAGET, R. N., K. C. B. etc., Commodore H. M. S. "Scylla"; Camera No. 10, Professor E. R. MARLE, B. Sc. (Lond.), F. C. S., Science Master, Methodist College, St. Johns; Camera No. 11, Dr. W. T. GRENFELL, Labrador Deep Sea Mission; Camera No. 12, Mr. W. E. SWAFFIELD, Hudson's Bay Company Agent at Cartwright.

Time-counter — Sub-Lieutenant VINEY, R. N., H. M. S. "Scylla."

Times of contact and visual observations—Sir WILLIAM MACGREGOR, M. D., C. B., K. C. M. G., etc., Governor of Newfoundland; Mr. A. C. CLEMINSON; Captain C. H. ELGEE, F. R. G. S.; Mr. HENRY REEVE, C. M. G.; Lieutenant REINOLD, R. N., H. M. S. "Scylla."

Shadow-bands—Mr. A. R. HOUSE.

To all the above our heartiest thanks are due, and particularly to Dr. JOEL STEBBINS, whose skilled assistance and fertility of resource were of great value to the expedition. This opportunity is taken to express our thanks also to Captain PARSONS and officers of the "Virginia Lake," to the Hudson's Bay Company and Mr. SWAFFIELD, its Agent at Cart-

THE FORTY-ONE-FOOT TELESCOPE AND THE INTRAMERCURIAL CAMERA, AT CARTWRIGHT, LABRADOR.

wright, and to the officials of the Red Cross Line and Reid-Newfoundland Companies. The four intramercurial lenses were loaned to the Lick Observatory by the Harvard College Observatory, and the five-inch lens of forty-one feet focal length by the Princeton Observatory.

Through the courtesy of Governor MacGregor and Commodore Paget, all the assistants were enabled to leave for St. Johns immediately after the eclipse on either the "Scylla" or the "Fiona," so that by 11 o'clock of the eclipse morning Mrs. Curtis and the writer were the only outsiders left in Cartwright. The "Virginia Lake" was so delayed by fog and stormy weather that it was sixteen days after the eclipse, on September 15th, before we finally left Cartwright. The first snow of the winter was then lying on its hills.

The limits of a scientific article forbid more than a mention of the novel and interesting features of life on the Labrador, the packs of wolfish Eskimo dogs, the simple "liveyeres" with their soft and pleasant speech in the quaint dialect of Devon, the sturdy fishermen from Newfoundland, and the great work which Dr. Grenfell is doing for his chosen people on this cruel coast. Of all these and of the workings of the great two-hundred-year-old Company, whose history is that of the whole Northland, we saw and learned much, and closed our two months' sojourn with nothing but regret at leaving the pleasant associations formed while on the Labrador.

VARIABLE SPOTS ON THE MOON.

By W. H. Pickering.

In number 104 of these *Publications* (p. 149) a paper is published under the above title. The author apparently does not recognize the fact that excepting in the case of specular reflection the angles of incidence and of reflection are usually unequal. The variable spots upon the Moon which have been most carefully studied are those of Eratosthenes and Alphonsus, both of which are near the center of the disk. The line of sight

is therefore nearly perpendicular to the reflecting surface under all circumstances, and the angle of reflection is zero. The angle of incidence, on the other hand, varies with the phase of the Moon, and it is necessary to explain the following facts: First, when the Sun is just rising on these craters, and for a day or two later, when the angle of incidence is still large, but little contrast is shown on the surface. Second, when the Moon is full, and the angle of incidence is reduced to zero, the variable spots become conspicuously dark, and the contrast between them and the rest of the surface is strongly marked.

If your correspondent will take the piece of white cardboard with the pieces of black paper pasted on it, to which he refers, and place it in the darkened room so that its surface shall be perpendicular to his line of sight, he will then be able to repeat his experiment under proper conditions. He must now show, first, that when the angle of incidence is small, and the ray of light is nearly perpendicular to the surface, the contrast between the paper and cardboard is strongly marked. Second, without altering his own position or moving the cardboard he must change the direction of the light so that it shall strike the cardboard obliquely, and he must now show that the contrast between the cardboard and black paper has disappeared. If he succeeds, he will doubtless let us know, and he will then have furnished a novel solution to a very difficult problem in selenography.

Your correspondent further explains the fact that a given region near the terminator is darker than the same region at full moon, by the presence of the shadows due to irregularities of the lunar surface. While the shadows produce a certain limited effect in this direction, the main reason of the difference of brightness is due to the variation of the angle of incidence. At full Moon the region is more brightly illuminated. This experiment your correspondent can also try for himself with a smooth ball.

October 27, 1905.

PLANETARY PHENOMENA FOR JANUARY AND FEBRUARY, 1906.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

First Quarter,	Jan. 2,	$6^h 52^m$	A.M.	First Quarter,	Feb. 1,	$4^h 31^m$	A.M.
Full Moon,	" 10,	8 37	A.M.	Full Moon,	" 8,	11 46	P.M.
Last Quarter,	" 17,	12 49	P.M.	Last Quarter,	" 15,	8 22	P.M.
New Moon,	" 24,	9 9	A.M.	New Moon,	" 22,	11 57	P.M.

The Earth is in perihedion on the morning of January 3d.

The first of the five eclipses of the year will occur on the night of February 8-9th, and will be a total eclipse of the Moon. It will be visible throughout the United States. The times of the principal circumstances are as follows (Pacific time):—

Moon enters penumbra,	February 8,	8^h	54^m	P. M.
Moon enters shadow,	February 8,	9	57	P. M.
Total eclipse begins,	February 8,	10	58	P. M.
Middle of the eclipse,	February 8,	11	47	P. M.
Total eclipse ends,	February 9,	12	36	A. M.
Moon leaves shadow,	February 9,	1	37	A. M.
Moon leaves penumbra,	February 9,	2	40	A. M.

The second eclipse will be a partial eclipse of the Sun on the night of February 22-23d, Pacific time, and will therefore not be seen in the United States. The region of visibility is the part of the Earth near the south pole, and in one place it extends far enough north to include a part of southern Australia.

Mercury is a morning star on January 1st, rising about an hour and three quarters before sunrise, and the interval is more than an hour until well after the middle of the month. It is therefore in good position for observation in the morning twilight. It reaches greatest west elongation on the afternoon of January 4th, and then begins slowly to approach the Sun, reaching superior conjunction on February 20th. It now becomes an evening star, and moves somewhat rapidly away from the Sun, but it is still too close for naked-eye observations at the end of the month.

Venus is also a morning star, rising less than an hour before sunrise on January 1st. Although it is much nearer the Sun than *Mercury,* it may be possible to see it in the morning twilight, on account of its great brightness, for a few days in early January; but its distance from the Sun is diminishing, and it reaches superior conjunction on the morning of February 14th. It is after this an evening star until November 29th, but will not move far enough away from the Sun to be seen in the evening twilight until after the middle of March. Several interesting conjunctions of *Mercury* and *Venus* with each other and with other planets occur during January and February, but most of them come when the planets are too near the Sun for naked-eye observations. *Venus* and *Mercury* are in close conjunction with *Uranus* on January 5th (distance 0° 6′), and on January 16th (distance 0° 19′), respectively. On February 22d *Venus* is in conjunction with *Saturn* (distance 0° 7′), *Mercury* with *Saturn* (distance 0° 17′), and *Venus* with *Mercury* (distance 0° 22′). They are at this date all evening stars, but are entirely too near the Sun to be seen.

Mars during January and February remains an evening star, setting at about 9 P. M. local mean time. This time changes scarcely at all during the period, being 9:05 on January 1st, and 8:58 on February 28th. The apparent distance of the planet from the Sun diminishes about 20° during the period, owing to the more rapid eastward motion of the Sun, but the planet is moving near a part of the ecliptic considerably north of the Sun's position, almost 15° at the end of February, and this materially retards its time of setting. Its actual distance from the Earth is still increasing somewhat rapidly, and in the middle of February is just about twice the mean distance of the Earth from the Sun. It is also growing fainter, but there will be no difficulty in identifying it.

Jupiter on January 1st is above the horizon until after 4 A. M., and on February 28th it sets at about midnight. It is in the constellation *Taurus* about 5° south of the *Pleiades* group, moves westward a little less than 1° until January 21st, and then moves eastward about 2° 30′ by the end of February.

Saturn is still an evening star on January 1st, setting at 8:40 P. M., local mean time, being about 4° west of *Mars* on this date, but its comparatively slow motion among the stars allows the Sun to rapidly approach it. On February 1st it sets

only two hours after sunset, and it comes to conjunction with the Sun on February 24th. It is in the constellation *Aquarius*, a region rather barren of bright stars, and moves 6° eastward and 3° northward during the month. As seen in the telescope in early January the ratio of major to minor axis of the rings is about 6 to 1. This will change to about 19 to 1 by June, and then increase slightly until the end of the year. Next year the Earth will pass through the plane of the rings and they will be seen edgewise.

Uranus is a morning star, having passed conjunction with the Sun in December, and is too near the Sun to be seen until late in February. At the end of February it rises about three hours before sunrise. It moves about 3° eastward in the constellation *Sagittarius* and is a little north of the group known as "the milk dipper."

Neptune passed opposition with the Sun late in December. and is above the horizon nearly the entire night in early January. It is in the western part of the constellation *Gemini*.

NOTES FROM PACIFIC COAST OBSERVATORIES.

NOTE ON THE FIVE-FOOT REFLECTING TELESCOPE OF THE SOLAR OBSERVATORY.

The five-foot reflecting telescope, work on which was begun in 1897 at the Yerkes Observatory, is now being completed, and will be erected on the summit of Mt. Wilson, where it will form a part of the equipment of the Solar Observatory of the Carnegie Institution. About one year's work was done on the five-foot mirror by the writer, while at the Yerkes Observatory, and much time was spent there upon the design of the mounting for the instrument. An account of this work, so far as it had progressed at the Yerkes Observatory, will be found in *Smithsonian Contributions to Knowledge*, Vol. XXXIV, 1904.

In April of this year the five-foot mirror and its grinding and polishing machine were brought to Pasadena. The mirror was protected from jar during transportation by an effective system of cushions and spiral springs, in connection with three boxes or cases, used one outside of another. The long railroad journey from Williams Bay to Pasadena was made without the slightest injury to the glass, and without affecting the perfect surface of revolution, as has been shown by optical tests since its arrival here. The mirror is being polished and figured in the Observatory instrument-shop in Pasadena, which is thoroughly equipped both for optical work on a large scale and for the construction of the metal parts of the instruments for the new observatory. As the instrument-shop was designed specially for this work, the arrangement and construction of the rooms of the optical department are unusually well-adapted to secure the conditions necessary in large optical work, such as constant temperature and freedom from dust; very complete facilities are provided also for the rigorous testing of optical surfaces.

Many of the metal parts of the five-foot reflector mounting are much too large to be machined in the observatory shop. These large parts are being made by the Union Iron Works Company of San Francisco; they comprise a very large proportion of the total weight of the mounting, and include the base casting, in two sections, the south and north bearings for supporting the polar axis, the polar axis, the float, the mercury trough, the fork, the short cast-iron part of the tube, the declination trunnions, the ten-foot worm-gear, the seven-foot bevel-gear, and some other minor parts. The polar and declination axes are hollow nickel-steel forgings, oil-tempered; they were hydraulic-forged, tempered, and rough-turned by the Bethlehem Steel Company, of Bethlehem, Pa., and are being finished at San Francisco by the Union Iron Works Company, all of the cylindrical surfaces being ground. It is expected that the Union Iron Works Company will finish their part of this work in three or four months from the present date. The heavy parts of the mounting will then be assembled at the observatory shop in Pasadena, where it will be necessary to construct a special temporary iron building, with a powerful crane for the purpose of erecting the mounting, as it seems indispensable that the instrument be completed, set up, and thoroughly tested in every way before being taken up the mountain.

All of the smaller and more complicated parts of the mounting will be constructed in our own shop, and this work is already well under way. These parts include the driving-clock and clock connections, the motor connections for quick and slow motions in right ascension and declination, the skeleton tube with interchangeable ends, the mirror cells, with the support systems for the mirrors, etc. The cutting and grinding of the teeth of the ten-foot worm-gear will also be done here.

G. W. Ritchey.

Solar Observatory Office, Pasadena.

The Orbits of Visual Binary Stars.

In *Lick Observatory Bulletin* No. 84 I have given the results of a study of all published double-star orbits. This paper will be of interest primarily to double-star observers, as it consists mainly of a table of the best orbit data (in my judgment) of those stars for which fairly satisfactory orbits have been

computed, and of notes showing the agreement of the predicted places with the most recent available observations.

Some general statements and conclusions based upon this paper and the study of which it is the result may be of wider interest.

It appears that orbits have been computed (or at least published) for only ninety-one different binary systems, restricting this term to the visual double stars,—that is, systems both of whose components have actually been seen in the telescope. Many of these orbits are based upon observed arcs so short or upon data of such doubtful value that they amount to no more than simple guesses, and are practically worthless. In fact, even by straining the definition of the term pretty badly, I was only able to say that fifty-three systems had "fairly satisfactory" orbits. These fifty-three orbits vary widely in value; many are still very uncertain, and of only thirty, or at most thirty-five, can it be said with reasonable confidence that future observations are unlikely to make necessary any great change in the elements.

The two double-star systems of which we have the most knowledge are those of *α Centauri* and *Sirius*, our two nearest neighbors among the stars; for not only do we possess very accurate orbits of these pairs based upon micrometric measures, but we also have relatively very exact values of the parallax of these two stars.

So far as accurate orbits are concerned, our knowledge of several other systems—e. g. *ξ Ursæ Majoris*, 42 *Comæ Berenices*, *κ Pegasi*, and *δ Equulei*—is also very satisfactory, and good observations for the next ten years will make it possible to say the same of nearly all the shorter-period binaries given in my list. When it comes to the orbits with periods of one hundred years or more, we must, for the most part, be content with a much slower rate of progress, and many of the long-period orbits must remain uncertain for one or more centuries.

Nor can we hope to make many additions to our list from the binaries in the Σ and OΣ catalogues for which no orbits have as yet been computed. In general these binaries have long periods, and the observed arcs are still very short, and nothing is more clearly demonstrated by the orbits hitherto published

than the futility of trying to determine a good double-star orbit from a short observed arc. It is seldom indeed that observations covering an arc of less than 180° will yield a reliable orbit, and it is safe to say that for most double stars an observed arc of at least three quadrants is necessary.

The number of well-determined binary-star orbits will be increased most rapidly by careful and systematic observations of the stars that have already shown considerable motion,—especially such pairs as β 80, β 513, β 648, Ho 212 etc,—and of the very close pairs of more recent discovery.

November 6, 1905. R. G. AITKEN.

OBSERVATIONS OF THE ECLIPSES OF *SATURN'S* SATELLITES.

More than a year ago Professor HERMANN STRUVE called attention* to the "cycle of eclipses and other phenomena of the satellites of *Saturn*" which began in 1904 and will extend over the next three years, but I have seen, so far, no published record of any observations of these eclipses. The following data may therefore be of interest:—

1905, Oct. 18; 36-inch telescope, power 350. Reappearance of *Enceladus* from eclipse noted at 15^h 16^m 40^s G. M. T. Predicted time,* 15^h 15^m G. M. T.

The time was noted when the satellite was seen with certainty. It was suspected nearly 2^s earlier. The sky background was good, but the seeing only fair, the images blurring badly at times.

1905, Oct. 26; 36-inch telescope, power 350. Reappearance of *Tethys* noted at 15^h 30^m 21^s G. M. T. Predicted time,* 15^h 29^m G. M. T.

Tethys was dimly seen for 5^s before the time noted. Observing conditions about as on Oct. 18.

1905, Nov. 10; 36-inch telescope, power 350. Reappearance of *Tethys* noted at 18^h 5^m 17^s G. M. T. Predicted time,* 18^h 4^m G. M. T.

The planet was low in the sky at the time of observation, and the seeing not very good. The time noted is the instant the satellite was dimly seen.

On October 28th, and again on November 14th, I tried to

* *Mon. Not. R. A. S.*, Vol. LXIV, p. 813, et seq, 1904.

observe the reappearance of *Mimas* with the 36-inch, but the seeing was poor on both nights, and the satellite was not seen. The search on each night was continued nearly 10^m after the predicted time of reappearance.

An attempt was also made on November 11th to observe the reappearance of *Tethys* with the 12-inch telescope. The seeing was very poor, and the satellite was first seen at 15^h 26^m 9^s G. M. T., the predicted time of reappearance being 15^h 23^m. From this it appears that the satellite was well out of the shadow of the planet before it was observed.

These observations indicate that there is no difficulty in observing the eclipses of any of the satellites of *Saturn*, except *Mimas*, with a large telescope. Under good conditions it would also seem probable that the eclipses of *Mimas* could be observed with the 36-inch telescope and those of *Tethys* with the 12-inch.

R. G. AITKEN.

November 20, 1905.

RETURN OF THE CROCKER ECLIPSE EXPEDITIONS FROM THE LICK OBSERVATORY.

The members of the three expeditions sent out by the Lick Observatory to observe the solar eclipse of August 29-30, 1905, have all reached home safely. Professor and Mrs. HUSSEY, of the expedition to Egypt, arrived at Ann Arbor, Michigan, early in October, and Professor HUSSEY at once entered upon the duties of his new position there.

Dr. and Mrs. H. D. CURTIS, of the expedition to Labrador, arrived at Mt. Hamilton on October 19th, and the members of the expedition to Spain, Director and Mrs. CAMPBELL and Dr. and Mrs. PERRINE, arrived on November 22d and November 20th, respectively.

Dr. CURTIS's account of work at the Labrador Station will be found on another page. Accounts of the other two expeditions will follow in our next number.

R. G. A.

VARIABLE ASTEROID (167) *URDA*.

The asteroid discovered August 23d by Professor MAX WOLF, and designated 1905 QY, on the assumption that it was new, was found by Dr. PALISA to be variable and very likely

identical with the known asteroid (167) *Urda*, though about a degree of arc from the predicted place of *Urda*. The estimates of magnitude were:—

	m
Berliner Jahrbuch, *Urda* at opposition........	12.9
WOLF, 1905 QY, August 23..............	11.3
PALISA, 1905 QY, August 31..............	11.0
PALISA, 1905 QY, September 5..............	12.0

In a letter to the central bureau at Kiel, August 28th, Professor A. BERBERICH practically established the identity by pointing out that in previous apparitions of *Urda* the magnitude has frequently been estimated from a half to a whole magnitude brighter than the value assigned by the *Jahrbuch*.

A short search was made here September 6th and 7th, in smoke and moonlight, without success, owing to the southern declination of the asteroid and to the roughness of the position data. An approximate ephemeris, computed by Professor BERBERICH, was received several weeks later, and the asteroid was readily picked up October 6th.

The following micrometer measures of position were made with the 12-inch refractor (*t* denoting $\Delta\alpha$ measures made by transits):—

H. M. T. 1905.	Star.	Number Comparisons.	(167) — ✱ $\Delta\alpha$	$\Delta\delta$	(167)'s Apparent α	δ	log $p\Delta$ α	δ
h m s			s	′ ″	h m s	° ′ ″		
t. 6, 12 07 52	2	6, 10	+ 10.49	— 7 25.0	22 10 33.37	— 11 10 05.8	9.524	0.791
12, 9 51 21	3*a*	16*t*, 10	— 36.82	— 3 44.1	22 09 34 38	— 11 19 59.4	9.133	0.815
19, 10 38 57	3*b*	6		— 9 11.3		— 11 25 26 8		0.798
19, 10 54 52	3*b*	10*t*	— 42.40		22 09 28.72		9.481	

MEAN PLACES OF COMPARISON STARS FOR 1905.0.

α	Red. to App. Place.	δ	Red. to App. Place.	Authority, etc.
h m s	s	° ′ ″	″	
22 11 39.80	+ 2.68	— 10 59 31.4	+ 18.8	⅓ (2 Paris 31795 + M1 30578).
22 10 20.20	+ 2.68	— 11 02 59.6	+ 18.8	BD. — 11°.5788. Micrometer connect'n with (1).
22 10 08.60	+ 2.60	— 11 16 33.6	+ 18.3	BD. — 11°.5786. " " (2).
22 10 08.60	+ 2.52	— 11 16 33.6	+ 18.1	BD. — 11°.5786.

Magnitude measures were made with the Rumford wedge photometer on three nights. On each occasion the comparison stars were BD. — 11°.5786 and — 11°.5787. These two were carefully compared, on five nights, with BD. — 11°.5777, which is given as 7.36 magnitude in the *Harvard Photometric Durch-*

musterung. The adopted magnitudes are 10.19 and 9.84. respectively.

G.M.T. 1905.	Settings on (167)	(167)	Rough Position of (167) (1905.0). α	δ	Remarks.
d		m	h m s	° ′	m
Oct. 20.70	16	13.43	22 09 32	—11 25.9	Faint *, 14.4±, 20″ west.
21.79	16	13.42	22 09 37	—11 25.9	Good conditions.
23.69	16	13.21	22 09 54	—11 26.0	" "

November 25, 1905. JAMES D. MADDRILL.

NOVA AQUILÆ, No. 2.

Nova Aquilæ continues to decline in magnitude, at a rate, however, only about half as rapid as during September, or about half a magnitude per month.

Occasional measures have been made with the Rumford wedge photometer, continuing the series published in the October number. The fainter comparison stars *f*, *g*, and *h* have not yet been used, and may not be required this year in photometric determinations. The star *x* is 2′ 27″ south of, and 11^s.0 preceding, *Nova*. Its magnitude from a single measure (three settings) is 11.83.

G. M. T. 1905.	Settings on *Nova*.	Comparison Stars.	*Nova*.	Weight.	Remarks.
d			m		
Oct. 3.66	16	*de*	11.04	4	Moon.
4.66	14	*d*	11.27	3	Moon shining on objective.
12.71	..	(*e*)	....	..	Usual brightness.
20.65	20	*de*	11.41	5	Good conditions.
23.65	20	*de*	11.31	5	Good conditions.
Nov. 2.63	12	*de*	11.68	3	Moon.
14.61	12	*de*	11.68	3	Fair conditions.
20.62	..	(*dex*)	11.8	1	Estimate: *d* 5 *e* 4 *v*; *e* 1 *v* 1 *x*.
24.65	20	*de*	11.90	2	Clouds.
25.61	16	*de*	11.88	4	Good conditions.

November 27, 1905. JAMES D. MADDRILL.

MORE NEW COMPANIONS TO KNOWN DOUBLE STARS.

In the beginning of the systematic survey of the northern sky for new double stars I was disposed to pass with a purely perfunctory examination those stars already catalogued as double; but it soon became apparent that the Σ stars and those in the other older catalogues yielded nearly as large a percentage of new doubles as did the stars previously regarded as

single. Usually the new pairs are so difficult that only a first-class modern telescope will reveal them; hence the fact that the earlier observers overlooked them is in no sense a reflection either upon their thoroughness or upon their keenness of vision.

The companions, which I have recently discovered, to the pairs Σ 614, Σ 625, Σ 2510, *h* 1492, and *h* 2082 are good examples of this class of objects, the new companions to Σ 614 and Σ 2510 especially being very difficult to measure. The results of my observations are as follows:—

Σ 614.

		A and B. New.		
1905.78	$120^\circ.5$	$0''.22$	9.2 — 9.2	3^n 36-inch.
		AB and C = Σ.		
1905.78	$68^\circ.2$	$4''.11$	8.5 — 9.2	2^n 36-inch.

Σ 625.

		B and C. New.		
1905.84	$226^\circ.8$	$0''.34$	9.7 — 10.5	2^n 36-inch.
		A and BC = Σ.		
1905.81	$115^\circ.9$	$4''.73$	8.5 — 9.3	1^n 36-inch.

Σ 2510.

		B and C. New.		
1905.66	$195^\circ.0$	$0''.25$	8.7 — 9.7	4^n 36-inch.
		A and BC = Σ.		
1905.63	$180^\circ.8$	$8''.66$	8.5 — 8.5	1^n 36-inch.

h 1492.

		B and C. New.		
1905.73	$175^\circ.1$	$0''.32$	9.7 — 10.1	3^n 36-inch.
		A and BC = *h*.		
1905.68	$54^\circ.9$	$18''.20$	9.0 — 9.2	1^n 36-inch.

h 2082.

		A and B. New.		
1905.82	$118^\circ.2$	$0''.38$	9.2 — 9.7	3^n 36-inch.
		AB and C = *h*		
1905.80	$125^\circ.5$	$16''.09$	8.7 — 10.0	1^n 36-inch.

The three Struve pairs have shown no motion since their discovery, and the Herschel pairs are too wide to be of interest as double stars.

R. G. AITKEN.

November 20, 1905.

COMET *b* 1905 (SCHAER).

The second comet of the year 1905 was discovered by SCHAER at Genoa the evening of November 17th. At the time of discovery it was within four degrees of the north pole. It has since moved south very rapidly, and crossed the equator on the 3d of December. The rapidity of this apparent motion was due principally to the fact that the comet was quite close to the Earth. At the time of discovery the comet was about twenty million miles away, less than one fourth of the distance of the Sun. Its nearest approach to the Sun was October 25th, when the distance was one hundred million miles.

Since discovery the comet has been receding from both the Earth and the Sun, and is becoming rapidly fainter. During December it will move southward through *Aquarius*.

The following elements of the orbit of this comet were derived by Mr. A. J. CHAMPREUX and myself from three observations made at the Lick Observatory on the 18th, 21st, and 25th of November; the first two by AITKEN, the last by SMITH. The method used is Professor LEUSCHNER'S "short method."

ELEMENTS.

$$
\begin{aligned}
T &= 1905 \text{ October } 25.02430 \\
\left.\begin{aligned}
\omega &= 132^\circ\ 07'\ 26''.8 \\
\Omega &= 223\ \ 04\ \ 08\ .3 \\
i &= 140\ \ 27\ \ 14\ .0
\end{aligned}\right\} & \ 1905.0 \\
\phi &= 74\ \ 41\ \ 13 \\
\log a &= 0.020856 \\
\log e &= 9.984301 \\
q &= 1.049195 \\
\log \mu &= 1.344119 \\
\text{Period} &= 160.6526 \text{ years}
\end{aligned}
$$

An attempt was made to pass a parabola through the three positions. The computations were made so as to represent

the three right ascensions and the second and third declinations. The resulting orbit left a residual in the first declination of $-38' 25''$. This residual being so large, the computations were then made without hypothesis regarding the eccentricity, resulting in the foregoing elements.

It may be of interest to computers to know that, by means of the "short method," within two hours after the residual from the parabola was determined, the general orbit (including the constants for the equator) given above, and the representation of the observations was finished.

The constants for the equator 1905.0 and an ephemeris extending to December 29th are given in *Lick Observatory Bulletin* No. 86.

Russell Tracy Crawford.

Berkeley Astronomical Department, Dec. 6, 1905.

GENERAL NOTES.

Distance of the Sun.—In *The Observatory* for October Mr. A. R. HINKS has a very interesting and readable article on " New Measurements of the Distance of the Sun." Some time ago Mr. HINKS published the results of a determination of the solar parallax from a number of plates taken at various observatories during the *Eros* campaign. The value of the parallax derived, 8″.797, compares very favorably with that found at the Cape of Good Hope, 8″.802, from heliometer observations upon *Victoria, Iris,* and *Sappho.* Mr. HINKS calls attention to the fact that these values of the solar parallax do not agree very well with the latest determinations of the constant of aberration. It was pointed out in No. 102 of these *Publications* that the latest determination of the aberration constant, by Professor DOOLITTLE, from over 15,000 observations, is 20″.54. A simple relation exists between the solar parallax and the constant of aberration, so that if one is given the other may be easily computed. The following table shows corresponding values of these two constants:—

Ab.	π
20″.46	8″.808
.48	.799
.50	.790
.52	.782
.54	.773
.56	.764

It will be seen from this table that if we adopt DOOLITTLE's value of the constant of aberration, or the value determined by Dr. CHANDLER, 20″.52, the corresponding value of the solar parallax will be considerably less than that given by the latest and most refined determinations by means of direct methods.

Mr. HINKS foresees a possible conflict between the direct and indirect methods of determining the solar parallax. Concerning this he says:—

"Suppose that in the course of time there should come to be a clear and definite agreement among the values found for the constant of the aberration of light, and that its value was (let us say) 20″.54, corre-

sponding, as this table shows, to a parallax of 8″.77, not 8″.80, on the assumption at least that the velocity of light is exactly determined, as it seems to be, and that the simple theory of aberration is correct.

"And suppose that by that time we are prepared to say quite definitely that the geometrical value is not 8″.77 but 8″.80. The most obvious solution of the difficulty would be to conclude that the simple theory of aberration is not true, and to hand over the problem to the mathematical physicists, who might in the result find that a definite geometrical determination of the solar parallax had provided just the criterion which they required to settle certain vexed questions in dynamics.

"Again, should further investigation confirm the conclusion that 8″.76 is the only value of the solar parallax which will reconcile the existing theory of the motion of the planet with the observed value of the constant of gravitation, it may be that the contradiction between the direct and the indirect methods will at last enable the dynamical astronomers to lay a finger upon that flaw which exists somewhere or other in the theory, and makes it impossible to say at the present time that all the motions of the solar system can be completely explained."

S. D. T.

Eine Spectrographische Bestimmung der Sonnenparallaxe, von F. KÜSTNER (*Astronomische Nachrichten, Nr.* 4048-49, *Bd.* 169).—In order to measure the radial velocity of a star with reference to the sidereal system it is necessary to eliminate that of the observer. We may look upon the observer's velocity as due to (1) the rotation of the Earth, (2) the revolution of the Earth and Moon about their center of mass, (3) the revolution of the Earth about the Sun, (4) the motion of the solar system in space. Of these the first is easily and accurately determined. The second is small enough to be in general negligible. The third requires a knowledge of the Earth's orbital velocity, which in turn depends upon the solar parallax, the value of which is probably not correct to within one fourth of one per cent. The fourth is not known with sufficient accuracy to justify its use.

From measures of the radial velocities, with reference to the Sun, of a number of stars distributed on all sides of our system it will be possible to determine (4). Similarly, from observations of the stars themselves we may obtain (3). It will be seen that by measuring the radial velocity of a star when the Earth is in a given position in its orbit, and then repeating the measure six months later, we can determine the Earth's orbital velocity, and hence the parallax of the Sun.

While the method has undoubtedly occurred to many interested in line-of-sight work, and the possibility of its use has been suggested by Professor CAMPBELL in his article in *Astronomy and Astrophysics* (Vol. XI, p. 319, 1892,), the present application of it is the first published so far as the reviewer knows.

In determinations of the Earth's orbital velocity it is advantageous to select a star near the ecliptic in order that the radial component of the Earth's velocity be as large as possible. *Arcturus* was chosen in the present case, and a series of eighteen plates of this star was taken with the spectrograph at Bonn, in June, July, December, and January, 1904-1905. These spectrograms were carefully measured, selecting sixteen of the best lines on each plate. The probable error of the measure of a plate is 0.22^{km}.

The velocity of *Arcturus* relative to the Sun obtained from eighteen plates was

$$V = -4.83 \pm 0.27^{\text{km}}. \quad \text{Epoch 1904.8.}$$

The Earth's orbital velocity $G = 29.617 \pm 0.057^{\text{km}}$, and hence the solar parallax $p = 8''.844 \pm 0.017$. As the results for the Earth's orbital velocity are relative, any error due to errors of wave-length is eliminated by using the same lines on every plate. This, of course, is not true for the absolute velocity of *Arcturus*, and hence the comparatively large probable error in V. A change in G of -0.100^{km} produces a change in p of $+0''.0296$, which shows to what accuracy one must determine the orbital velocity of the Earth spectroscopically. In fact, Professor KÜSTNER does not regard the above determination of the solar parallax as of any value in itself, but rather as indicating the possibility in the future of determining this constant from spectroscopic measures. The method possesses some advantages over the older ones. Systematic errors, which in the other methods are difficult to eliminate, need not be feared so much here, since the measures are relative. Also we may extend the series of observations as much as we please, so that we are not confined to short intervals as in the case of planet oppositions or transit of *Venus* observations. It will, however, be necessary to use a number of stars in order to eliminate errors which might arise from small variations in the star's velocity due to its being a binary. The suggestion is

made that observatories could co-operate in this work and use the standard velocity-stars already available for this purpose.

While Professor KÜSTNER may be a little optimistic in regard to the spectrographic determination of solar parallax, especialiy with the present power of astronomical spectrographs, his paper is very timely, and there is reason to hope that in the near future spectroscopic observations of radial velocity will reach the accuracy required to make such determinations comparable with those of the older methods.

J. H. MOORE.

Evolution of the Solar System.—The *Astrophysical Journal* for October contains an interesting article by Professor F. R. MOULTON under the title at the heading of this note. The writer gives a résumé of the work done by Professor CHAMBERLIN and himself in developing the spiral theory as a possible explanation of the evolution of the solar system. They claim that LAPLACE'S nebular hypothesis, or ring theory, is no longer tenable, but in giving up this theory we should not overlook the fact that LAPLACE put forth his theory as a mere hypothesis and never claimed that it was a true explanation of the development of the solar system. Dr. MOULTON'S article is too long, and perhaps too technical, to be discussed in these notes. The concluding paragraphs, however, are very suggestive, and may with profit be quoted here:—

"While only abstracts of a portion of the discussions have been made in this paper, enough has been said to show that the spiral theory is even now a good working hypothesis. It explains all the phenomena upon which the ring theory rested, and many others which are contradictory to the ring theory. Nothing has yet been found which seems seriously to question its validity.

"The spiral theory raises a whole series of new and difficult questions in celestial mechanics. These are the immediate effects of the tidal forces which are developed by the near approach of two suns, the perturbations of the orbits of matter which has been ejected by one of them under a variety of conditions, and the secular evolution of the orbits of this ejected material. A large amount of labor will be required to carry the discussion of these questions to a successful conclusion.

"The spiral theory is fertile in suggesting new considerations for interpreting the immense variety of special phenomena of the system. It is not too much to expect that it may suggest new questions for

observational investigation. It affords geologists new conceptions of the early history of the Earth. But perhaps its most interesting contribution is to our general philosophy of nature. Heretofore we have regarded the cosmical processes as forever aggregating matter into larger and still larger bodies, and dissipating energy more and more uniformly. Now we recognize important tendencies for the dispersion of matter. This idea has introduced an element of possible cyclical character in the evolution of the heavenly bodies, though the question of the source of the requisite energy is serious. There is hope that the difficulties of this question may soon be relieved, for recent discoveries respecting the internal energies of atoms suggest the possibility that the Helmholtzian contraction theory explains the origin of only a part of the energy given up by the stars."

S. D. T.

Canals of Mars.—The canals of *Mars* have been photographed at the Lowell Observatory by Mr. LAMPLAND. Professor LOWELL contributes an article on the subject to the November number of *Popular Astronomy*, but the reproductions there given are indistinct, and do not apparently show the canals at all.

New Asteroids.—In number 4050 of the *Astronomische Nachrichten* Professor BAUSCHINGER, head of the Recheninstitut in Berlin, assigns numbers to sixteen of the small planets discovered and sufficiently observed during the current year. The total of numbered asteroids is now 569. Seven of the recently discovered planets were not considered sufficiently well observed to merit a number.

Zodiacal Light.—Professor SIMON NEWCOMB contributes an article to the October number of the *Astrophysical Journal* in which he describes some observations on the zodiacal light made from a mountain in Switzerland. He was in such a latitude that in midsummer the Sun was about 20° below the northern horizon at midnight. The Sun would be far enough below the horizon to completely cut off twilight, but if the zodiacal light extends in all directions from the Sun to any considerable distance it should be visible at midnight at the station selected. Professor NEWCOMB's observations indicate that the light was faintly visible, and he suggests that we hereafter frame our definition of zodiacal light as follows: "A

luminosity surrounding the Sun on all sides, of which the boundary is nowhere less than 35° from the Sun, and which is greatly elongated in the direction of the ecliptic."

A New Algol Variable.—Bulletin No. 6 of the Laws Observatory is devoted to the determination of the period of a new *Algol* variable discovered by Madame CERASKI in the fall of 1904. This star has been observed since June of this year at the Laws Observatory, and its period has been found to be $2^d\ 19^h\ 56^m\ 44^s$, with an uncertainty of perhaps five seconds. This star is remarkable both for the rapidity and the amount of the diminution of its light. It decreases over three magnitudes in four and one-half hours and becomes so faint as to be invisible with the small telescope of the Laws Observatory. The average diminution in light of stars of the *Algol* type is about 1.4 magnitudes. S. D. T.

Standard Time.—In volume IV, appendix IV, *Publications of the U. S. Naval Observatory,* Lieutenant-Commander EDWARD EVERETT HAYDEN, head of the Department of Chronometers and Time Service, sets forth the present status of the use of standard time. After defining standard time and referring to the international date-line, he explains in some detail the method employed in sending out time-signals from a central observing station, together with the method of obtaining correct standard time. Reference is made to a resolution passed by the Eighth International Geographic Congress which met in September, 1904, in which the congress expressed itself as favoring the universal adoption of the meridian of Greenwich as the basis of all systems of standard time. In a summary of nations that use standard time it is shown that of sixty-four all but twenty have adopted the Greenwich meridian as the basis, and of those twenty no two refer to the same standard meridian. The pamphlet is evidently intended to arouse popular interest in the universal adoption of standard time by all nations, and emphasizes the desirability of using the Greenwich meridian as the basis of the system. The author would call this the "Universal Time System," and says that it "may fairly be said to have as much in its favor as the Gregorian calendar itself." The pamphlet

further contains legal acts, decrees, and decisions relative to standard time and a table of abstracts of official reports of the kinds of time in use by various nations. Those interested in any point connected with standard time or time service will find a very clear discussion of it in this article.

ELLIOTT SMITH.

Star Catalogue.—Professor J. G. PORTER, of the University of Cincinnati, has recently published a catalogue of the northern stars of PIAZZI, containing 4,280 stars for the epoch 1900 (*Publications of the Cincinnati Observatory,* No. 15). As explained by Professor TUCKER in the preface to his catalogue of the southern Piazzi stars, the completion of this catalogue renders available observations of the complete list for four epochs well distributed throughout the last century,—that is to say, for the mean epochs 1800, 1835, 1875, and 1900. The reduction of the original observations of PIAZZI has been undertaken by Dr. HERMAN S. DAVIS, who proposes also to discuss the observations available for the four given epochs. It is anticipated that valuable data concerning precession and proper motions will be derived from this discussion.

ELLIOTT SMITH.

*Astronomische Beobachtungen zu Kiel. **Beschreibung der** Neuen Meridiankreisanlage von* PAUL HARZER.—A description of the new meridian circle recently installed at Kiel has been published by PAUL HARZER, director of the Observatory. Accompanying the description are six illustrations showing in detail the salient features of the instrument.

All modern improvements known to meridian-circle observers accompany this instrument. The reversing is done by a crane from above suitably fitted with crank and gear-wheels. Right ascensions are observed by means of a so-called ***unpersönliches*** micrometer, and at the same time the declination setting is made. At the eye-end of the telescope is an apparatus for recording the declination setting, but the author states that the micrometer-head is so quickly and easily read that the recording apparatus will probably not be used in observing.

Electric lights are used for illumination, and two motors furnish power for opening and closing the shutters. The

instrument is provided with a mire, collimators, a nadir and zenith mirror, and, to eliminate possible errors due to changes in the observing-clock, one under the conditions of constant temperature and pressure has been installed. As each of these possesses some new features, a detailed description, as given in Professor HARZER's article, will be of value to those interested in the subject. ELLIOTT SMITH.

The following notes have been taken from recent numbers of *Science*:—

The conference of the International Union for Co-operation in Solar Research was concluded on September 29th, in New College, Oxford. It was resolved to accept the invitation of M. JANSSEN to meet at Meudon in September, 1907. Professors SCHUSTER (chairman) and HALE were elected members of the executive committee. It was decided that the central bureau should be at the University of Manchester, and that the computing bureau should be at the University Observatory, Oxford, under the direction of Professor TURNER. Committees were elected to deal with the following four subjects: (1) standards of wave-length; (2) solar radiation; (3) co-operation in work with the spectro-heliograph; (4) co-operation in work on the spectra of sun-spots.

Professor G. E. HALE, director of the Mount Wilson Solar Observatory, on September 30th, gave a lecture in the Cavendish Laboratory, Cambridge University, on "The Development of a New Method in Solar Research," and on October 4th he gave a lecture at a special meeting of the Royal Astronomical Society on the "Solar Observatory on Mount Wilson, California."

Professor C. W. PRITCHETT has retired, at the age of eighty-three and after thirty years of service, from the professorship of astronomy and directorship of the Morrison Observatory of Pritchett College, at Glasgow, Missouri. His successor is Mr. HERBERT R. MORGAN, formerly computer in the United States Naval Observatory. The Morrison Observatory has a twelve-inch Clark equatorial and a six-inch meridian circle.

Dr. HERMAN S. DAVIS on November 1st resigned the position of Astronomer-in-Charge of the International Latitude Observatory at Gaithersburg, and has been succeeded by Dr. FRANK E. ROSS, formerly Research Assistant of the Carnegie Institution. Dr. Ross still retains some connection with the work which Professor NEWCOMB is doing under the auspices of the Carnegie Institution.

Obituary.—Number 4051 of the *Astromomische Nachrichten* announces the death, on October 3d of this year, of Dr. WALTER F. WISLICENUS, in the forty-fifth year of his age. Dr. WISLICENUS served as student assistant in an expedition for the observation of the passage of *Venus* in 1882. He occupied the position of assistant in the observatory of the University of Strassburg from 1883 until 1889. In 1889 he became "Privatdocent" in the University of Strassburg, and "ausserordentlicher Professor" in the same University in 1894. He had marked ability in the exposition of astronomical and physical facts and theories, and the power to present them in such a way as to arouse the interest of his hearers or readers. Until the last seven years of his life his published writings consisted of memoirs or small volumes, some on matters of interest to professional astronomers only, but more of a popular or semi-popular nature. He is best known for the great service which he rendered the science of astronomy by the publication of the *Astronomische Jahresbericht,* an annual indexed review of published articles of interest to astronomers. This annual was founded by him, and six volumes were published under his direction and under the auspices of the Astronomische Gesellschaft. The seventh volume was under preparation at the time of his death. His removal at a time when his career seemed only begun deprives the astronomical fraternity of one of its most devoted and trusted members. B. L. N.

The Late Astronomer-Royal for Scotland.—Professor RALPH COPELAND died at Royal Observatory, Edinburgh, on 27th of October last. He was sixty-nine years of age. He was born in Lancashire, where his father was a farmer and part owner of a cotton-mill. His tastes did not lie in the direction of business, and he went to Australia in 1853. Amongst the

most treasured possessions which he carried with him was his scanty library, consisting of three volumes—HERSCHEL's "Outlines of Astronomy," a Bible, and a copy of SHAKESPEARE's plays. For a time he was engaged on a sheep-farm, and at the gold-diggings. Returning to England in 1858, he relieved the monotony of the voyage by a study of DONATI's comet. He was apprenticed to a firm of engine-builders in Manchester. Here he not only began the regular study of mathematics but erected for himself a small observatory. In 1864 he studied French at Paris, and in the following year went to Germany, where he may be said to have commenced his scientific career while studying astronomy in the University of Göttingen. In 1869 the degree of Ph.D. was conferred on him for his work, the "Göttingen Star Catalogue," carried out in conjunction with his friend, CARL BÖRGEN. In 1870 Dr. COPELAND was appointed astronomer to the Earl of Rosse at Parsonstown, where he had the use of the great six-foot reflecting telescope. He remained with Lord ROSSE until 1874, when he joined Lord LINDSAY in an expedition to Mauritius to observe the transit of *Venus*. He afterwards became assistant to Dr. ROBERT BALL at Dublin. Here he remained till 1876, when he was offered by Lord CRAWFORD the directorship of his observatory in Aberdeenshire. In 1882 he again observed the transit of *Venus*, this time at Jamaica. Dr. COPELAND was one of the few who have observed each of a pair of transits of *Venus*. In later years he organized and carried out four eclipse expeditions. In 1889 Dr. COPELAND was appointed Astronomer Royal for Scotland and Professor of Astronomy in the University of Edinburgh. One of the first duties of his new office was the choice of a site for the new Royal Observatory. In May, 1896, the observatory was formally opened. The discovery of the new star in the constellation *Perseus* in 1901 entailed a great amount of labor and assiduous personal observation. Of Professor COPELAND's scientific achievements, reference may be made to his proof of the identity of the orbit of the comet of 1880 with that of 1843, the orbit computed by him, as well as those computed by two other astronomers, agreeing so well as to leave no reasonable doubt that the paths of the two bodies were one. He identified the iron lines in the spectrum of the comet of 1882, and in 1886 he proved the existence of helium

in the Great Nebula in *Orion*. His many great and varied services to astronomy, especially in the department of spectroscopy, render his death a distinct loss to astronomical science.—*Extract from the Scotsman.*

Minutes of the Meeting of the Board of Directors, Held in the Rooms of the Society November 25, 1905, at 7:30 P. M.

President Townley presided. A quorum was present. The minutes of the last meeting were approved. The following members were duly elected:—

List of Members Elected November 25, 1905.

Mr. W. F. Armstrong	1645 Fulton St., S. F., Cal.
Mr. E. H. Bacon	508 Montgomery St., S. F. Cal.
Mr. A. J. Champreux	Students' Observatory, Berkeley, Cal.
Mr. Frank V. Cornish	Crossley Building, S. F. Cal.
Mr. Sturla Einarson	Students' Observatory, Berkeley, Cal.
Dr. T. J. J. See*	Naval Observatory, Mare Island, Cal.
Dr. Otto Tetens	Goettingen, Germany.

A * signifies life membership.

The following resolutions were, upon motion, adopted:—

Resolved, That the income of the John Dolbeer Fund for the fiscal year 1905-1906 be devoted to the *Publications* of the Society.

Resolved, That the January, 1906, meeting of the Society be held in the Students' Observatory of the University of California at Berkeley.

Resolved, That the Observatory of Hiram College, Hiram, Ohio, be placed upon the list of corresponding institutions.

The proposed amendment to Article IX of the By-Laws, referring to date and place of meetings of the Society, was referred by the President to a committee consisting of Messrs. Campbell, Leuschner, and Ziel for investigation.

Adjourned.

Minutes of the Meeting of the Astronomical Society of the Pacific, Held in the Lecture Hall of the California Academy of Sciences November 25, 1905, at 8 P. M.

The meeting was called to order by President Townley. The minutes of the last meeting were approved.

The Chairman gave a short account of the work of the Society, calling attention to the recently created status of "Patrons of the Society," and giving a summary of the benefactions of those whose names have been placed on this list. He then introduced the lecturer of the evening, Professor Leuschner, Director of the Students' Observatory at Berkeley, who read his paper on the "Derivation of the Orbits of New Comets, Asteroids, and Satellites."

Adjourned.

OFFICERS OF THE SOCIETY.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
(February, April, June, August, October, December.)

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